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Organisation of Export Groups

There may be several methods available for the successful organisation of an Export Group, but we feel that they must all conform to the same general system because of the necessity for collaborating very closely with the appropriate Government Departments. Within the foundry industry there is room for quite a large number of such Groups, some being concerned with articles consisting practically entirely of castings, whilst others will concern themselves with aggregations of castings and forgings in the form of machinery. The second type can be represented by the Internal Combustion Engine War Export Group, and we express our indebtedness to this body for having placed at our disposal Supplement No. 1, which details the steps to be taken to place Groups on a proper footing, especially with regard to the securing of raw materials necessary for manufacturing articles for export. The Industrial Supplies Department of the Board of Trade is the high authority, and this body is now responsible for the allocation to the Export Groups of the totals of controlled materials, the chairman of each Group being responsible for the apportionment amongst the members of the Group of the totals so allocated. The controllers of the Ministry of Supply then regulate the supply to the members of the Group subject to the conditions set out on the official forms.

In almost any Group, border-line cases will come up for discussion, and a solution may be found either by the formation of an additional Group or by joining a more appropriate one. It is thus desirable initially to define as clearly as possible the nature and range and goods to be covered by a Group. The next step is to define what is covered by the export trade, and the Internal Combustion Engine Group have clearly set out their list as follows :—

(*a*) Dominion, Colonial or foreign Governments.

(*b*) Crown Agents for the Colonies.

(*c*) The member's own overseas agents or distributors, or subsidiary or associated overseas selling organisation.

(*d*) Manufacturing or merchanting firms or buying houses or contracting firms in the United Kingdom for shipment overseas, either separately or as part of any installation, plant, or equipment, to any purchaser other than a Government Department of the United Kingdom or in connection with any contract with any person other than such a Government Department.

(*e*) Any other customer overseas.

It is worth noting that export trade does not include orders directly from, or for re-sale to, Government Departments in the United Kingdom even if intended for ultimate shipment overseas.

The next important step for a Group to take is to prepare and have approved by the Board of Trade and the controllers of iron and steel, non-ferrous metals, aluminium and timber, forms for stating the consumption of these materials in 1938. On their completion they should be sent as a confidential document to the secretary of the Group. A further set of forms covering the above raw materials will have to be provided covering the estimated requirements for the twelve months ending on March 31, 1941, and these, too, should be placed as confidential documents in the hands of the secretary or other official of the Group. Finally, a quarterly return will also have to be made confidential to the secretary of the Group, the Board of Trade and the Export Council of the export business affected. If the various Groups follow the system outlined, it should not be difficult to place the whole conduct of their business on a routine basis. Groups now in formation can have their procedure made easy by adapting to their own particular requirements the system evolved by the Internal Combustion Engine Group and approved by the authorities. We are quite sure that that body will provide Groups in process of formation with copies of its system. The address of the secretary is 32, Victoria Street, London, S.W.1. There may be a tendency in some sections of the foundry industry to imagine that because they do no direct export business this question of forming Export Groups does not concern them. If they are selling to merchants who export, then the onus is upon the foundry, as the middleman cannot tell the authorities the nature and quantities of the raw material requirements necessary for the continuation of the business. If, on the other hand, foundries are making components to be built up into machinery, then they can await demands from their customers as to weights used up in past periods for the fulfilment of these orders. Although the constant completion of forms may seem a time-absorbing nuisance, yet for the proper conduct of the country's trade it is a current essential.

D

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Electric Furnace Melting Costs

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In reading Mr. Button's Paper on "General Steel-Foundry Practice," published in your issue of May 30, I noticed his statement that high-frequency furnaces on steel melting cost less to operate than arc furnaces, and also your footnote that your information was that operating costs approximate to those of an electric arc furnace of equal capacity.

This is a subject which has been gone into in much detail by myself in past years, and both statements appear to me to be a little ambiguous. My own findings are that total costs, *i.e.*, operating costs plus amortisation costs, of running a high-frequency furnace are rather less than those of running an arc furnace of equal capacity within the capacity range in which high-frequency furnaces are usually built. The operating costs, *i.e.*, the costs apart from the amortisation costs, are appreciably less than an arc furnace of the same size.

Since the capital cost of a high-frequency unit is so very high, the total costs are influenced to a large degree by the amortisation rate fixed, but if this is fixed on a reasonable basis, say 12½ per cent. per annum, it will be found that there is quite a marked difference in the total operating costs compared with an arc furnace of similar size. The current consumption is usually rather less, there are no electrode costs, the lining costs are somewhat dearer, and the labour costs less.—Yours, etc.,

F. W. ROWE.

Penistone Branch Works,
David Brown & Sons (Hudd.), Limited,
Penistone, near Sheffield.
June 1, 1940.

Publications and Malleable Production

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have always admired the editorials of THE FOUNDRY TRADE JOURNAL, and feel I must congratulate you on your recent article praising the publications of the Institute of British Foundrymen, in particular the "Report on Melting Furnaces for Grey Cast Iron." Although the work of the Institute in past months has, *force majeure*, been rather disappointing, and at a time when it is most needed, this publication and the new volume of transactions are of the greatest value.

The former in particular is of great interest and completeness. In including particulars of modern tilting crucible furnaces I believe it is doing a great service. It has always seemed to me that this type of furnace merits a greater measure of attention than has been afforded it in the past, in the ironfoundry, particularly for small-scale production of special irons, *e.g.*, of the austenitic type and blackheart malleable.

On my first acquaintance with the malleable industry, only six years ago, my foundry manager gave me convincing proof of the possibilities of malleable, melted in a crucible. A charge of blackheart malleable (Si 0.9 per cent., T.C 2.4 per cent.) melted in an oil furnace and cast into test-bars, was annealed in an oxidising packing, and annealed under a standard whiteheart schedule of 136 hrs., with the following remarkable results:—Yield point (tons per sq. in.), 26.6; ultimate tensile strength (tons per sq. in.), 37.2, and elongation per cent. on 2 in., 7.6.

Such a material, annealed from 30 to 36 hrs., as a blackheart iron, would yield an excellent product, capable of replacing many small steel castings and forgings, and would be of particular value in these times. For a small engineering firm using up to 5 tons per week of small forgings and castings, an oil- or gas-fired tilting furnace of 7 to 10 cwt. capacity, melting three heats per day, would be a sound proposition. Although the melting costs of such a unit are high, as compared with other furnaces, the capital cost is low, and the furnace would be working to capacity under these conditions, which is a necessity in all plants now.

Although the crucible furnace is used to some extent in small-scale whiteheart malleable production, I believe there is no producer using it for the purpose and in the way I have suggested.—Yours, etc.,

H. N. KNIGHT.

4, Spring Street, Stockton-on-Tees,
Co. Durham.
May 24, 1940.

Health Insurance and Pension Contributions

From July 1 new rates of contributions will be payable under the Health Insurance and Pensions Scheme, consequent upon the Old Age and Widows' Pensions Act, 1940. The stamps will then cost 1s. 10d. for men (increased from 1s. 8d.), for women 1s. 5d. (from 1s. 2d.), 11d. (from 10d.) and 9d. (from 7d.) being recoverable from the men and women employees respectively. A point to note also is that with women eligible for Old Age Pension at 60, ordinary contributions for such employees cease at that age, special contributions on special cards applying, the stamps costing 8d. and the employer paying the whole contribution. Ordinary contributions cease at 65 for men (as now), but the special stamps (the whole payable by the employer) will cost 11d. (increased from 10d.).

In some cases the ordinary contributions on ordinary cards will continue to be paid for "over 60" women, the employee paying her share as when under 60. This provision applies to women who, although 60, may not at that age have qualified for pension (*e.g.*, not having then registered the necessary five years insurance to secure pension).

The contribution rates for ordinary voluntary contributors (not the new special voluntary contributors recently brought into the scheme) will also be increased from July 1 next. Under the combined scheme, the stamps for men will cost 1s. 10d. (from 1s. 8d.), for women 1s. 5d. (from 1s. 2d.); if insured separately, contributions for pensions will be for men 1s. 1d. (from 11d.), and for women 8½d. (from 5½d.). If insured separately for Health Insurance, the contributions are 9d. and 8½d. (as now) for men and women respectively.

Under Unemployment Insurance, the rates continue as now, but ordinary contributions will cease for women at 60 in all cases, special stamps and cards being required for "over 60" workers (instead of at the age of 65, as now), the stamps (the whole payable by employer) costing 8d. For men ordinary contributions cease at 65, the special stamps for "over 65" male workers costing the employer 9d. The special cards cover both Health Insurance and Pensions and Unemployment Insurance, there being a space for each scheme on each card.

Book Review

Hardening and Tempering Engineers' Tools. By George Gentry. Published by Percival Marshall & Company, Limited, 60, Kingsway, London, W.C.2. Price 1s. 6d.

This book, having proved its worth to the amateur mechanic, has now been republished as an enlarged and revised edition. In this particular field it well covers the subject, and also gives a few elementary notes on the forging of steel.

Random Shots

An old lady in the habit of giving her pet dog a daily lump of sugar says that now that the ration is reduced she no longer feels justified in thus spoiling him. She asserts that every time she has to refuse little Fido his titbit a lump comes into her throat. At this juncture, of course, she should sip her tea before the lump disappears and continue to give the sugar to the dog.

* * *

Apropos of sugar, there is no truth in the report that a certain Control in the Ministry of Supply wrote the other day to a firm of core-oil manufacturers asking if they could use saccharine instead of molasses.

* * *

It appears that in what has been officially called "panic buying," ladies' silk stockings have scored record sales. Who will blame the ladies at this critical time for wishing to put their best leg forward?

* * *

Our Cryptic Language!

A little girl was seen to be studying a large notice nailed up on a tree in Kew Gardens, which read "Bird-nesting strictly prohibited." "I do call that silly!" said the youngster scornfully, when she had thoroughly taken it in. "Can the birds in Kew Gardens read, then?"

* * *

A partner to that story is the one of a small boy who went fishing at a spot where he "didn't oughter." He was sitting silent and still at the water's edge, lost in thought, when the Voice of Authority suddenly called out. "Can't fish here, boy."

"No, I don't think they can," replied the lad, after thinking the matter over carefully in his mind.

* * *

At a certain Assizes recently a sailor, charged with attempted murder, was acquitted. It was decided that he had acted only under extreme provocation. It appears that the day after arriving home on leave after six months in the North Sea, his young brother had pestered him to take him to the swimming baths!

* * *

A prominent foundryman claims to be having great success with welding, which he has taken up as a wartime economy measure. When pressed for further information, he admitted that his efforts were restricted to the bathroom, where he was making a habit of welding, whilst in his bath, all the odd scraps of soap on to the new tablet in order to use them to the bitter end.

* * *

"Hi, Dopey, stop whistling while you work," said the manager to the newest and youngest member of the staff.

"I'm not working," replied the youngster brightly.

* * *

The proprietor of a country cycle shop says that he is having to cope with an extraordinary demand for bicycle locks. It appears that even the children are putting their scooters and tricycles out of action at night so that no parachutist will be able to use them.

"MARKSMAN."

Institute of British Foundrymen's Conference

The annual conference of the Institute of British Foundrymen, which was to have been held at Cheltenham on Friday and Saturday of this week, has (as announced in the JOURNAL last week) been cancelled.

Formation of Inclusions in Steel Castings*

By WALTER CRAFTS, JOHN J. EGAN and W. D. FORGENG

Although many elements reduce the tendency to porosity in steel castings, manganese, silicon, aluminium, calcium, titanium and zirconium appear to be most generally suitable for the purpose. The manganese and silicon contents are usually maintained in a fairly constant range. Silicon-killed castings often are made to be sound with little or no addition of the stronger degasifiers. In many cases, however, it is more practical to utilise the stronger degasifying elements, aluminium, calcium, titanium and zirconium. Since they greatly modify the composition, shape and distribution of the non-metallic inclusions, and thereby the ductility, the strong deoxidisers must be used in such a way as to form the least harmful types of inclusions.

As the reasons for failure always to obtain good results have not been obvious, an effort has been made to determine the mechanism of solidification of steels deoxidised to produce certain types of inclusions. Diagrams representing the mechanism of their formation have been constructed from the appearance of the non-metallic constituents and have not only illustrated the limiting features of specific deoxidising treatments with respect to inclusion formation and ductility, but have also indicated a relation between inclusions and resistance to hot tearing.

TABLE I.—*Average Ductilities of Grade B Steel Castings.*

Typical inclusions.	Type.*	Approx. aluminium addition. Per cent.	Elongation in 2 in. Per cent.	Reduction of area. Per cent.
Silicate	I	None	30	49
Eutectic ..	II	0.05	23	35
Alumina ..	III	0.10	27	42

* Designation used by Sims and Dahle.

Three different types of deoxidation treatment have been used for obtaining sound castings with relatively high ductility. The first method is to make and cast the steel under such conditions that deoxidation with silicon and a small addition of a strong deoxidiser assures soundness. The effective addition that will promote soundness without causing the formation of intergranular inclusions varies with the furnace practice and composition, but may be limited to about 0.025 per cent. Al, Zr or Ti. Up to 0.10 per cent. Ca and 0.15 per cent. V are also used for this purpose. The inclusions in these steels are characteristically glassy silicates and round or irregular sulphides. As pointed out by Sims and Lillieqvist,[1] the formation of fine intergranular inclusions, which are detrimental to ductility, limits the amount of strong deoxidisers that may be added.

The second type of treatment is the large aluminium addition suggested by Sims and Dahle.[2] The amount of aluminium added (0.10 to 0.20 per cent.) is sufficient to cause the separation of an immiscible oxide phase and to form a minimum of harmful eutectic inclusions. Some average ductilities reported by Sims and Dahle for grade B steel castings were as shown in Table I.

A third type of treatment has been described by Grotts,[3] in which the high aluminium addition of Sims and Dahle is supplemented by treatment with calcium-silicon. The average results of tests under commercial conditions in which the steel was treated with 0.125 to 0.175 per cent. Al were reported as in Table II. Similar results were obtained by Gagnebin[4] when using an intermediate (0.06 per cent.) aluminium addition, together with calcium, zirconium or beryllium under special conditions of oxidation and order of additions.

TABLE II.—*Average Results of Tests under Commercial Conditions.*

Deoxidation.	Yield point. Tons per sq. in.	Tensile strength. Tons per sq. in.	Elongation in 2 in. Per cent.	Reduction of area. Per cent.
Plain ..	19.2	32.1	29.2	46.2
Ca-Si ..	20.2	33.0	31.2	54.2

The present inclusion study included the examination of both commercial steels and steels made at the Union Carbide and Carbon Research Laboratories. The experimental heats of the latter were made in a basic high-frequency furnace crucible, starting with a low-carbon charge. No slag was carried and all additions were made in the crucible. This practice resulted in a metal somewhat more oxidised than comparable commercial steel. In some tests calcium alloys were added either in the form of loose lumps or wrapped in a light perforated sheet-steel capsule that was plunged into the metal. Unless otherwise noted, the steels contained approximately 0.30 to 0.35 per cent. C, 0.75 to 1.00 per cent. Mn, 0.015 per cent. P, 0.035 per cent. S, and 0.35 to 0.50 per cent. Si. Some heats were also made in the ranges of 0.005 to 0.010 per cent. and 0.050 to 0.060 per cent. S.

Typical mechanical properties of double-keel block castings made according to the different types of deoxidation treatment outlined above are give in Table III. The steels were normalised from 925 deg. C., annealed from 900 deg. C., and tempered at 200 deg. C. for 24 hours.

TABLE III.—*Mechanical Properties of Castings.*

Deoxidising additions. Per cent.		Yield point. Tons per sq. in.	Tensile strength. Tons per sq. in.	Elongation. Per cent.	Reduction of area. Per cent.
Al	Ca				
	0.10	18.3	35.0	32.0	57.0
0.05		19.6	34.8	17.5	36.5
0.10		22.3	33.8	27.5	40.4
0.10	0.10	22.1	36.6	30.0	50.0

Inclusion Solidification Diagrams

Various degrees of deoxidation produce different kinds, shapes and arrangements of inclusions, and these differences have been utilised to construct diagrams illustrating the solidification process. For this purpose five inclusion types have been chosen, corresponding to types resulting from graduated additions of aluminium, and, in one test, calcium. No effort has been made to review all possible kinds of three-component systems likely to be found. Three types—silicate, alumina and peritectic—correspond to the three common deoxidation treatments described above, and the eutectic and galaxy types represent intermediate undesirable conditions. The types of inclusions found in typical steels treated with graduated amounts of aluminium are indicated in Table IV.

The metal-oxide-sulphide type of ternary solidification diagrams that have been constructed on the basis of these inclusion types has been previously used by Benedicks and Löfquist[5] and Wentrup[6] to illustrate roughly quantitative diagrams of simple systems of iron and non-metallics. The data for such basic diagrams are extremely limited, and the presence of carbon, manganese, silicon, aluminium, etc., as well as lack of equilibrium conditions, makes it impossible to construct quantitative solidification diagrams for the non-metallics in deoxidised steel. The compositions of the oxide and sulphide phases under various conditions of deoxidation are not known, and knowledge of the pertinent oxide-sulphide systems is inadequate. However, efficient use of deoxidising elements has demanded rough working diagrams even though they are wholly qualitative and limited to specific conditions. A series of diagrams was prepared on the basis of the inclusion types described in Table IV. Obviously, the "binary" and "ternary" systems illustrated were only simplified conjectural representations of the complex systems that are actually present in steel.

Certain assumptions have been necessary in order to interpret the mechanism of formation of inclusions from their appearance, shape, size and distribution. In addition, the extrapolation from a limited oxide-sulphide ratio to a "ternary" metal-oxide-sulphide diagram has entailed assumptions regarding the metal-oxide, metal-sulphide, and oxide-sulphide "binary" diagrams. The construction was also simplified by ignoring the delta-gamma peritectic reaction in iron. The oxide-metal system was considered to have an extended miscibility gap, and for convenience the eutectic was placed near the oxide rather than the metal phase. The sulphide-metal system is also shown with a range of limited solubility. While the diagrams have been constructed with respect to deoxidation with aluminium, examination of the inclusions in steels treated with titanium or zirconium has indicated, with the exceptions below, very similar mechanism of solidification.

In constructing the solidification diagrams, the different kinds of inclusions have been classified with respect to their mechanism of formation according to the following assumptions:—

(1) Random oxides (silicate or alumina) are formed at a liquid miscibility gap.

(2) Round sulphides and oxide particles distributed in a rough network formation are formed as binary eutectics between metal and sulphide, and metal and oxide, respectively. In higher aluminium steels, translucent round sulphides are formed as a binary eutectic between metal and an oxysulphide compound.

(3) Intergranular fine sulphides represent a ternary eutectic between metal, sulphide, and oxide or oxysulphide compound.

(4) Galaxies, or clusters of oxide particles, similarly represent a ternary eutectic between metal, oxide, and oxysulphide compound.

(5) Duplex inclusions having a geometrically shaped oxide core and sulphide-like periphery are formed by an incompleted peritectic transformation from oxide to oxysulphide compound.

By the nature of their construction, the diagrams constructed obviously illustrate only the specific steels studied, even though the data have been extrapolated to form ternary diagrams to assist in understanding the manner of solidification. Further, it cannot be emphasised too strongly that the diagrams not only are not quantitative but are conjectural in many respects. They have been constructed to serve

* Extracted from a Paper presented to the American Institute of Mining and Metallurgical Engineers; the authors are on the research staff of the Union Carbide and Carbon Research Laboratories Inc., Niagara Falls, N.Y.

as a guide to the deoxidation of steel castings and have answered several anomalies and indicated more effective means of utilising deoxidisers.

After detailing the nature of the various types of inclusions the authors have drawn the following conclusions.

Probably by reason of elimination of galaxy inclusions, the ductility of steels of the peritectic type is usually superior to that of the alumina type. The addition of calcium with the aluminium, titanium or zirconium makes the sulphur content less critical and provides a buffer against irregularities in distribution of the deoxidiser that might lead to formation of galaxies in zones of relatively low deoxidiser content. Steels of the peritectic type seem to have the same degree of resistance to hot tearing that has been found in the strongly deoxidised steels that are not treated with calcium. Typical properties of experimental steels containing about 0.035 per cent. S are given in Table V.

TABLE IV.—*Types of Inclusions.*

Type.	Aluminium addition. Per cent.	Ductility.	Non-metallic inclusions.*
Silicate	0.025	Very good	Glassy silicates, round sulphides, and (intergranular sulphide films).
Eutectic	0.05	Poor	(Alumina), round sulphides and intergranular sulphide films.
Galaxy	0.075	Poor	Alumina, round sulphides and (intergranular sulphide) films or oxide galaxies.
Alumina	0.10	Fairly good	Alumina, round sulphides and (intergranular sulphide films or oxide galaxies).
Peritectic	0.10 (0.05 Ca)	Good	Alumina, duplex, round sulphides, and (intergranular sulphide films).

* Parentheses indicate appearance only in small amounts.

Summary and Conclusions

A series of schematic diagrams has been presented to illustrate the mechanism of formation of non-metallic inclusions in steel castings treated with graduated amounts of strong deoxidisers. In reconstruction of the mechanism of solidification from the character of the non-metallic inclusions in steel castings, the most important, and least well substantiated, assumption is that large additions of aluminium, titanium and zirconium produce a separate, additional phase in their respective oxide-sulphide systems that has been designated as an oxysulphide compound. However, the metallographic evidence for the existence of such compounds appears to be convincing. The two different forms of ternary eutectic (oxide galaxy and intergranular sulphide) would indicate two ternary systems divided by the quasibinary system of metal and oxysulphide compound. The presence of an oxysulphide compound between the oxide and sulphide phases in the oxide-sulphide "binary" system is also predicated by the formation in calcium-treated steels of inclusions that appear to have been formed by a peritectic reaction.

The references to such an aluminium oxysulphide compound are summarised by Mellor[7] and are typified by the studies of Gautier,[8] who reported the formation of an aluminium oxysulphide compound as a result of action by hydrogen sulphide on aluminium oxide. The subject does not appear to have been studied very critically and no data suitable for the construction of the aluminium oxide-aluminium sulphide equilibrium diagram have been located in a search of the literature. Inconclusive studies have been made by the present authors on commercially purchased aluminium sulphide and on material prepared by treatment of molten aluminium with sulphur. Although all samples were contaminated with oxygen, at least one different atomic lattice structure has been found, in addition to that of alumina and that reported by Hanawalt, Rinn and Frevel[9] for aluminium sulphide. The possibility of allotropic forms of sulphide has not been eliminated, and it is considered that formation of an aluminium oxysulphide compound has not been firmly established. In spite of the uncertainty, however, it is believed that the appearance of the inclusions in the steel is sufficient to justify, for the present purpose, the assumption of the presence of an oxysulphide compound in steels treated with large (0.10 to 0.20 per cent.) amounts of aluminium, titanium or zirconium.

In summarising the implications of the solidification diagrams, it should be emphasised that the metallographic observations of the inclusions were quantitative, that the derived empirical diagrams are both simplified and not quantitative. The high ductility usually obtained in steel of the silicate type when treated with large (0.10 per cent.) additions of calcium is understandable, as calcium does not appear to form inclusions of the oxysulphide compound type and has only a minor influence on the intergranular sulphide ternary eutectic. The proneness to hot tearing of steels of the silicate and eutectic types is also explained by the absence of the oxysulphide compound as a buffer between atmospheric oxidation and the intergranular eutectic, which seriously lowers the resistance of steel castings to hot tearing. Conversely, the alumina and peritectic types are relatively resistant to hot tearing at the oxidised surface owing to the formation of separated oxide particles rather than continuous intergranular films.

It is obvious from the diagrams that a close balance is required in steels of the alumina type to maintain high ductility by avoiding either oxide galaxies or intergranular sulphides. The maximum sulphur content that is permissible for good ductility has been indicated to be in the range of 0.040 per cent. for the experimental steels treated with high aluminium or titanium, and slightly above 0.050 per cent. for steels treated with zirconium. In the interest of economy the minimum effective amount of strong deoxidiser (about 0.10 per cent.) is usually added, and the necessity for thorough diffusion to avoid oxide galaxy and intergranular sulphide inclusions is obvious. For this reason the more dilute and readily soluble addition alloys are usually more effective; for example, calcium-manganese-silicon alloy has often been found to be more reliable and efficient than the more highly concentrated calcium-silicon alloy. Calcium, when used in conjunction with 0.10 to 0.20 per cent. of aluminium, titanium or zirconium to produce inclusions of the peritectic type, provides a measure of safety by minimising any tendency to low ductility caused by oxide galaxies. The ductility of steel of the peritectic type approaches closely that found in steel of the silicate type, and in addition the steel treated with larger amounts of strong deoxidisers is more resistant to hot tearing.

It is believed that the solidification diagrams represent broadly the mechanism by which the inclusions were formed. Interpretation of the appearance of inclusions by empirical reconstruction of the solidification mechanism, however, at best is only a substitute for quantitative equilibrium diagrams, but until such information is available diagrams of an empirical character appear to be useful. They must, however, be applied with great care and can be utilised only to indicate trends, except under the exact condition used for construction of the diagrams.

TABLE V.—*Typical Properties of Experimental Steels.*
(0.035 PER CENT. SULPHUR).

Deoxidising additions. Per cent.					Yield point. Tons per sq. in.	Tensile strength. Tons per sq. in.	Elongation. Per cent.	Reduction of area. Per cent.	Izod. Ft.-lbs.
Ca	Al	Zr	Ti	V					
0.05	0.10				23.6	34.6	27.0	44.9	30.5
0.05		0.10			20.5	34.9	27.0	42.2	32.5
0.05			0.10		20.3	33.4	26.5	38.8	25.3
0.05	0.075	0.075			20.9	33.7	28.5	44.0	35.0
0.05	0.075		0.075		23.6	35.5	27.5	45.2	32.0
0.05	0.05	0.05	0.05		22.9	34.6	29.0	48.2	33.0
0.05	0.075			0.075	22.7	35.0	28.5	48.9	37.3
0.05	0.04	0.04	0.04	0.04	23.4	34.4	29.0	49.5	38.0

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A.R.P. and Light Measurement

The present lighting restrictions have brought into prominence the problem of measuring the intensities of very faint lights, both in and out of doors, states DR. E. H. RAYNER, Chief of the Electricity Department of the National Physical Laboratory, in the Annual Report, published recently. For many purposes measurement of the illumination is not necessary, but it suffices to say whether a light falls below some fixed standard, and a simple portable gauge has been designed to do this even in the hands of an unskilled observer. The instrument contains no lamp, the illumination of the comparison field being provided by radium luminous compound.

Advice on Uses of Tin

The International Tin Research and Development Council, of Fraser Road, Greenford, Middlesex, announces that it has accumulated much experience, particularly since the war began, on a wide range of processes in which tin is directly or indirectly concerned, and that this experience is available to our readers without charge. These processes include:—Grease-tinning and hot-tinning; soldering; bearings and bearing materials; bronze castings; electro-tinning; fusible alloys, particularly for rapid die and punch mounting, tube bending, etc. Advice can sometimes be given by correspondence, but as in many cases personal contact is much more effective, the Council is prepared to send members of its staff to give assistance and advice at readers' works.

Moulding a 100-Ton Three-Ram Press Casting

By R. F. COATES and J. KING

The failure of a large machine tool, especially when there is no similar machine available to perform its duties, calls for immediate action towards replacement. A 100-ton three-ram press which had been in continual use for 35 years fractured as a result of overload. There was no certainty of early delivery of a new casting from the machine-tool industry; furthermore, the original makers of the press had destroyed the pattern. Ransomes & Rapier, Limited, of Waterside Works, Ipswich, agreed to make the casting, and the problem was then fully discussed as to whether they should make a new pattern. This was ruled out owing to the delay involved and the cost of making such a pattern.

FIGS. 1 TO 6.—STEPS IN THE MOULDING OF THE PRESS CASTING.

In accepting this work the management had to decide upon all aspects of the moulding operations, such as sands, tackle, cupola and ladle capacity, performance of lifting gear, etc., as this casting was above their usual limits of size and weight. The old casting weighed just over 9 tons and certain modifications were required to increase its strength and—especially in view of the fracture—it was stiffened up by steel plates bolted on all sides before passing it to the patternmakers for the necessary modifications, core prints and core boxes, etc. In the meantime, tackle was being assembled in the foundry in preparation for moulding as soon as the old casting was ready. The moulding box used was 12 ft. square and two large iron tie bars were let into the floor to form the base and link up with two similar bars in the top part of the mould. A coke bed was laid and the bed of the mould rammed up. The ribs and other irregularities of the pattern were measured up and the bed cut accordingly to receive the pattern.

Improvising a Pattern

It will be appreciated that this "pattern" had anything but a pattern finish and circumstances did not permit a covering of three-ply. It was therefore decided to place strips of wood around the pattern to thicken up and to facilitate drawing. From just below to just above the bottom edge, pig-iron was placed to prevent straining at these points, with the possibility of metal entering the coke bed.

Four ingates were set in position on the flange on the bottom—two at the table and two on the top flange. When the bottom was half rammed up the pattern was loosened by suspending a large weight from the overhead crane and using it in the form of a battering ram. At suitable places packings were fixed in position half-way up on the sides of the box to form a base upon which grains could be wedged to hold the cores at the sides. The bottom was then completely rammed up and the joints made, a drawback being made to form the rounded head.

Openings were made when ramming the top to receive the grains for the holding down of the cores. Two risers were placed over the table end for the feeding of the heavy section, which was 6 in.; other parts were 2½ in. thick. Downgates were so placed as to permit of casting by three ladles: one at the table end, one at the bend and the other for the top ingates. After the top was taken off and the drawback withdrawn, the top flange was taken out and the pattern was then drawn with comparative ease. As the mould was being finished conical iron bases were set in position on which to place the grains to support the cores. To be effective, they had to be directly under a cross-section of the core irons, and to get the exact positions the core irons were lowered into the mould and the positions marked.

Moulding and Coremaking

Fig. 1 shows the finished mould, and in preparing for drying the sides of the moulding box were bricked up to a suitable height. On the bricks steel rails were placed to support the portable dryers and a covering of sheet iron. The mould during the course of being dried is shown in Fig. 2. The top is shown in Fig. 3. A group of the cores is shown in Fig. 4. Iron packings were placed on the bottom of the irons and up to the top face of the cores to give an "iron to iron" bearing when holding them in position. The large core for the bend was made in two parts (Fig. 5), the smaller core being bolted to the larger one after drying. Pipes were used to connect the coke vents from the larger to the smaller, to ensure a free passage for gases and so that no metal should make an entry.

With the cores in position and supported on all surfaces (Fig. 6), tie bars were placed in the top of the mould to match up with those below the bottom plates. These bars were lowered and secured at the bottom through holes in the ends. They were tightened up by using the overhead crane and then wedged in. The top grains were then wedged as well as the sides of the box. This method proved very effective, and it is most important on such work because of the very heavy stresses exerted during the cast.

FIG. 7.—TOP OF MOULD, SHOWING TOPS OF DOWNGATES.

The tops of the downgates were made of loam cores and can be clearly seen in Fig. 7, which shows the top of the mould as it was turned over. When casting, the downgates to the bottom flange and the table-end were opened first. When it was estimated that sufficient metal had entered to make the bottom and side walls, the downgates to the top flange were then opened. This allowed a stream of hot metal to flow over the top of the mould and ensured a good fusion of the large grains.

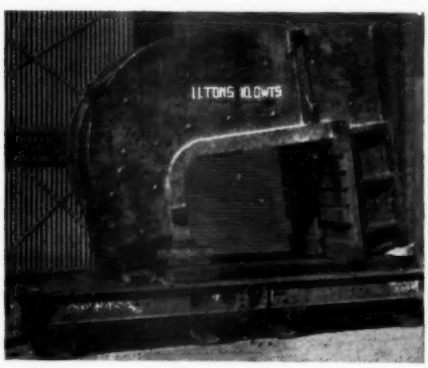

FIG. 8.—THE FINISHED CASTING.

The time taken for casting was 1 min. 50 sec. The metal used was Meehanite (Grade E.1), having a tensile of 17.8 tons per sq. in. (the old casting was of iron giving only 9 tons per sq. in.). After a suitable time had elapsed following the cast, all runners, weights, bars, etc., were released to allow a free course for contraction. The finished casting is shown in Fig. 8.

Deformation and Flowability Tests of Moulding Sands*

By R. CHADWICK

The testing of foundry moulding sands and moulding materials has become recognised as being a fundamental operation in the production of sound castings, and to minimise the cost of production and foundry losses. The knowledge obtained by the standard methods of testing moulding sands, together with the available technical data on record, can give the foundryman sufficient information as to what type of sand can be used for the particular type of castings to be made. Most foundrymen today are familiar with the testing equipment which is available and the tests which are employed, but perhaps are not so familiar with the more recent investigations as to the deformation and flowability properties of a moulding sand. Mr. Wm. Y. Buchanan has recently published some interesting information[1] on the subject, and his conclusions concerning deformation are:—

(1) Deformation is definitely related to the percentage flowability as expressed by the methods put forward; (2) deformation should be used as a method of judging mixing efficiency, and (3) the deformation test is useful and a good figure for normal practice should be easily established, *e.g.*, 0.025 in. per in. for Scottish rock sand.

TABLE I.—*Samples of Silica Sand with Increasing Proportions of Clay and Comparative Test with Coal Dust.*

Green compression strength. Lbs. per sq. in.	Deformation in thousandths of an inch per 1-in. length.			
	7 per cent. coal dust + 10 per cent. clay.	10 per cent. clay.	15 per cent. clay.	20 per cent. clay.
1.0	1	1	2	1
1.5	—	2	—	—
2.0	2	5	3	2
2.5	—	*(2.5) 17	—	—
3.0	3	—	4	3
4.0	4	—	5	4
5.0	4	—	6	5
6.0	6	—	7	6
7.0	8	—	8	7
	*(7.4) 16	—	*(7.6) 24	—
8.0	—	—	—	9
9.0	—	—	—	13
				*(9.8) 32
Percentage flowability	77	84	76	70
Percentage moisture in sand mixture ..	4.9	4.9	5.7	6.7

Note.—Increased water was added as the clay was increased, in order to keep the plasticity of the clay approximately constant. * Maximum crushing strength.

Owing to the broadness of such a subject, to deal with it fully would occupy a Paper of much greater length than the present one; it is therefore the author's intention to give briefly the definitions of these properties, and the results obtained by the investigations carried out on (*a*) samples of silica sand with increasing proportions of clay; (*b*) the effect of coal dust, and (*c*) ironfoundry green sand with increasing proportions of moisture. Finally a few conclusions are drawn from the results of the experiments.

Definition of Deformation

Deformation is defined in the A.F.A. Handbook "Testing and Grading of Foundry Sands and Clays" (1938) as being "the change in shape which a moist sand undergoes when subjected to pressure." This is more fully described by Dietert as follows:—"Moulding sand, like other materials, may possess a satisfactory strength, but the strength is considerably limited due to a property which may be termed 'deformation.' For example, when a material is brittle, then its load-carrying power is very limited. Moulding sand may become 'short' or brittle though the strength is satisfactory."

W. G. Reichert[2] further explains that "It is this property which prevents drops if the flask distorts slightly when lifted, it is this property which gives flexibility to the sand and allows it to receive considerable core print pressure without failure. It will allow pattern plates to be constructed so that considerable green-sand crush may be carried at the parting line, thereby eliminating fins. It may be described as the ability of sand to stand abuse in the foundry. On the other hand, if the deformation of the sand is too great it allows the metal to swell the mould, resulting in opening the mould at the parting line and causing runouts."

Definition of Flowability

Flowability is defined in the A.F.A. Handbook "Testing and Grading of Foundry Sands and Clays," 1938, as "The mobility of a foundry sand by virtue of which it fills the recesses and moves against pattern surfaces not necessarily in the line of squeezing or ramming force."

Dietert states: "The flowability of moulding sand is influenced by moisture content, permeability, fineness, clay content, strength, and facing material additions. It may be controlled by increasing or decreasing any one of the above physical properties until suitable flowability is secured. A moulding sand with a flowability of 90 will ram readily, and is conducive to producing a uniform casting surface, while a sand with a flowability of 75 will require more ramming energy and is conducive to inferior casting surface."

In each series of tests undertaken the flowability was determined by means of a special accessory attached to the A.F.A. standard rammer, and the deformation was determined on the Dietert universal testing machine with a special attachment, at progressively increasing green compression strength until the test-piece collapsed. Each test quoted represents the average of at least three tests which were in satisfactory agreement.

Referring to Table I, it will be seen that as the percentage of clay increases from 10 to 20 per cent., the maximum compression strength increases from 2.5 to 9.8 lbs. per sq. in. The maximum deformation increases from 17 to 32 thousandths of an inch, and the flowability decreases from 84 to 70. When 7 per cent. coal dust is added to 10 per cent. clay and milled, it increases the compression strength from 2.5 to 7.4 lbs. per sq. in., making it similar in compression strength to the mixture with 15.0 per cent. clay (7.6 lbs. per sq. in.), but the deformation of the coal dust mixture is considerably lower than that of the 15 per cent. clay mixture, *viz.*, 16 as against 24 thousandths. In other words, these tests confirm that when the sand is milled with coal dust, although the bond is increased and may appear to be satisfactory, it tends to be short and brittle.

Referring to Table II, it will be seen that when the percentage of clay and coal dust is constant, but the percentage of moisture is increased beyond the point at which it gives maximum green compression strength, *viz.*, from 4.2 to 6.4 per cent., the compression strength diminishes from 6.0 to 3.0 lbs. per in. The deformation increases from 13 to 25 thousandths. The slight improvement in deformation by increased moisture from 5.5 to 6.4 per cent. is more than counteracted by the loss of green bond strength, and the fact that there is more water vapour to be removed from the sand when the metal is poured into the mould. It would appear that the better way of improving the deformation of the mixture at 4.2 per cent. moisture would be to increase the percentage of clay instead of increasing the moisture. The percentage flowability slightly increases from 79 to 83. The increased moisture has resulted in slightly increasing the flowability, and this is probably due to the fact that the clay is rendered less sticky and is therefore probably not satisfactory in practice. The flowability would probably be equally good by adding rather more clay, but keeping the moisture down to about 4 to 4.5 per cent.

Conclusions and Recommendations

(1) There is a definite relation between the flowability and deformation.

(2) These properties are most easily controlled by varying the clay content or the moisture content, but the means adopted must depend on other properties required of the sand. For instance, increased clay content will result in reduced permeability and flowability, with increased deformation, but it must be remembered that if too high a deformation is obtained, there would be a tendency for the mould to swell when pouring the metal, and so there is a limit as to how much clay can be added in practice. On the other hand, increased moisture beyond a certain point is likely to cause obvious troubles, and this method cannot be used beyond certain limits.

TABLE II.—*Ironfoundry Green Sand* (10 *per cent. Clay* + 7 *per cent. Coal Dust*) *with Increasing Proportions of Moisture.*

Green compression strength. Lbs. per sq. in.	Deformation in thousandths of an inch per 1-in. length.		
	4.2 per cent. moisture.	5.5 per cent. moisture.	6.4 per cent. moisture.
1.0	1	2	2
2.0	2	5	4
2.5	—	—	15
3.0	4	8	*(3.0) 25
4.0	5	*(4.0)24	—
5.0	6	—	—
6.0	*(6.0)13	—	—
Flowability..	79	80	83

* Maximum crushing strength.

(3) The flowability test is most useful, in the control of hardness; a sand having low flowability would require greater ramming effort, and a hard mould surface would result, with low permeability.

(4) In order to obtain the fullest information, the deformation should be recorded at intervals as the increased load is applied to the test-piece, and the results obtained plotted by means of a graph. It will be noticed that most sands steadily deform until the yield point is reached, then there is a sudden increase and the test-piece collapses.

Finally, the author wishes to thank the firm with which he is employed for the permission given to carry out the experiments, and for use of the equipment.

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* An entry for a Short Paper Competition organised by the Middlesbrough Branch of the Institute of British Foundrymen.

Producing Sound Castings in Iron

By P. D. PINCOTT

This Paper, which was read before the May meeting of the London Branch of the Institute of British Foundrymen, over which Mr. Barrington Hooper, C.B.E., presided, is of much the same character as several of the Papers which were to have been presented at the Cheltenham Conference. Its study is recommended as a useful contribution to current problems. The author is foundry superintendent of J. & E. Hall, Limited, Dartford.

The object of this Paper is to review and examine as closely as possible some of the difficulties connected with unsoundness in cast iron, and selecting, as specific examples to illustrate the cause and effect of this trouble, several castings produced by the company with which the author is associated. It is not intended that a comprehensive survey be made of such problems as are experienced throughout the entire range of cast irons, but rather to concentrate on the group of moderately low-carbon and low-phosphorus irons which are used to a great extent in engineering where pressure and arduous working conditions prevail.

Unsoundness can first of all be appreciated as a word having a distinctly broad meaning when applied to describing castings. It is known as an expression which conveys in a simple manner the fact that a casting is defective. Nevertheless, as it indicates neither the cause nor extent of the trouble, some relation must exist between the defect and the purpose for which the casting is designed. In this Paper, therefore, mainly concerning pressure work, the use of the word shall be to indicate a condition of local porosity, or radical change in structure which has been influenced by shrinkage.

Apart from certain processes, the properties of an iron will mainly depend upon its chemical composition, namely, the quantities of carbon, silicon, manganese, phosphorus and sulphur, in relation to the section, and thermal history. It is proposed that each of these elements shall be selected in turn, and individually examined to show what effect they have on soundness when used in varying proportions.

Influence of Carbon

Carbon, by virtue of its absorption in pure iron in quantities up to and including 4.3 per cent., presents a remarkable field of ferrous material in which, at approximately 2.0 per cent. carbon, there is a dividing line; the material containing the lower percentage of carbon is of course steel, and that with the higher quantity is cast iron. In actual fact the dividing point is purely arbitrary as steel containing more than 1.7 per cent. carbon has little application. Cast iron likewise is seldom found to have less than 2.4 per cent. carbon. Visual inspection shows a distinct dissimilarity of the two separate groups of the iron-carbon alloy, and with the exception of the type of iron known as white iron the difference in appearance is accounted for by the form in which part of the carbon exists. As the quantity of carbon increases, so also is the solution of iron carbide increased. An extremely hard constituent, when it is present in large quantities, produces an iron limited in application unless subjected to thermal treatment.

Effect of Silicon

The modern production of pig-iron and also foundry irons does in many instances bear some relation to the foregoing, and consists of a steel base converted to grey iron by means of carbon absorption and graphitised with the aid of ferro-alloy additions. At one time, however, cast iron was always produced under conditions where several so-called impurities were present and an excess of iron carbide was therefore infrequently encountered. Foremost among the impurities, silicon, in addition to lowering the amount of carbon necessary to form the eutectic, reduces the solubility of carbon in iron, and a soft flaky graphite is thrown out.

It will naturally be accepted that with an increase in the quantity of graphitic carbon present, the quality of the iron as a whole will be reduced to a coarse and weak condition by virtue of the size and multiplicity of the cleavages created. Strength and solidity being essential features of an industrial metal or alloy, it becomes obvious that some form of control must be instituted to restrict the size and quantity of graphite as much as possible in order to make any satisfactory progress in this direction. Whatever the method employed, it is not difficult to comprehend the strides which have been made, and to-day cast iron is characterised by the smallness of the graphite particles and the proximity of the matrix to eutectoid steel composition. It is perhaps unfortunate that, with so much achieved, a further problem should be created or at least accentuated, namely, shrinkage.

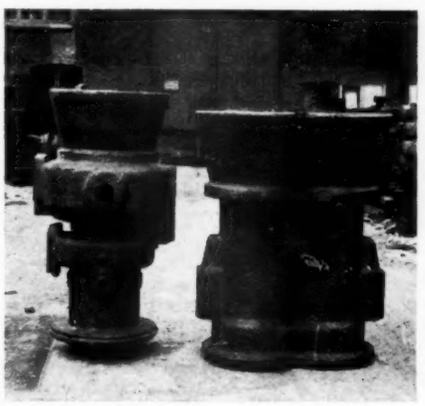


FIG. 1.—AMMONIA-GAS COMPRESSOR CYLINDERS WITH FLARED TYPE OF FEED HEADS.

Shrinkage

Shrinkage is a natural phenomenon and can be described broadly as the decrease in volume which takes place when the temperature of metal falls from that at which it was poured, down to atmospheric temperature. Throughout this transformation of the liquid to solid and down to relatively low temperatures, several constitutional changes occur which vary to some extent with the composition of the metal. Cast iron of eutectic composition, for example, changes as a whole from liquid to solid at 1,130 deg. C. When the composition, however, is such that it is above or below eutectic value, the liquidus and solidus points separate proportionately to the margin of departure from the eutectic to produce what is known as the freezing range wherein liquid and solid coexist. As the densities and coefficients of contraction of these two appear to differ, it will be readily understood that as one moves farther away from eutectic composition, so are the difficulties associated with the production of sound castings also somewhat increased.

It must be considered, then, why it is necessary to depart from what may appear to be the ideal composition when compounding furnace mixtures. When the temperature of molten cast iron is lowered, the amount of carbon present influences the freezing point in the following manner. If less than the amount necessary to produce the iron carbon eutectic, then austenite crystals containing approximately 1.7 per cent. carbon commence to grow and continue until the remaining fluid increases in carbide richness and finally the eutectic composition, 48 per cent. austenite and 52 per cent. carbide, is reached; then solidification takes place.

Graphite Formation

If carbon is present in a larger quantity, and sufficient to attain the exact iron-carbon eutectic, then no freezing range will exist and the entire liquid changes to solid. The solubility of carbon increases with an increase in the temperature of the iron, and graphite in turn is produced from the dissociation of the iron carbide; then the higher the temperatures of carbide formation the easier it breaks down and ejects graphite with a slow fall in temperature. Therefore, an iron containing more than the eutectic amount of carbon becomes supersaturated and graphite is thus thrown out of solution previous to the metal solidifying.

From the foregoing it will be observed that at least two kinds of graphite are formed, one produced from the unstable carbide above the solidus point and another from carbide at and below the solidus.

The quantity and size of graphite are seriously affected by the rate of cooling, and it will be seen that as the mass or section of a casting increases, graphite can assume undesirable proportions unless restricted by either quick cooling and subsequent retention of carbon in solution, or a reduction in the graphitising medium, or finally by keeping the total amount of carbon in the iron sufficiently low. Of these factors, cooling, with the exception of chilling, is accepted as constant, varying only to a very slight extent in the choice of moulding material, and can therefore be ignored.

The two remaining factors, being related, show that carbon in excess of the eutectic composition is to be avoided in castings of anything but very light sections. As the mass increases the eutectic mixture produces an open structure and in work of even moderate section it becomes necessary to control the composition to a point below that which appears theoretically the optimum to obtain a satisfactory close structure. Several processes or methods are used for the control of graphite size; nevertheless, it will be found that the resulting iron is invariably a low-carbon or hypo-eutectic mixture.

With a reduction in carbon, the expansion which occurs in cooling due to the growth of graphite carbon is somewhat reduced, and shrinkage increases the nearer the composition of steel is approached. Little can be done to restrain this action, and it becomes necessary to adjust founding technique, as will be described later.

The nature of silicon in controlling the physical condition and properties of cast iron has already been referred to by its ability to dissociate iron carbide to liberate carbon in the form of graphite. In promoting this change, it becomes a factor which decreases shrinkage to a point where all the carbon is converted to the free variety. Control of the amount of silicon is of equal importance to the control of total carbon.

Influence of Manganese

Manganese as one of the components performs several interesting and beneficial actions. First, by an affinity for sulphur it is very effective in preventing the formation of excessive quantities of hard and brittle iron sulphide. A second feature refers to the powerful deoxidising properties it possesses which is inestimable in the melting of iron, and more particularly steel. In fact, with the rapid advancements in later years of the quality and strength of cast

iron, a good deal of the credit for these achievements must be due to the use of steel in varying proportions as part of the furnace charge as a means of reducing the carbon content.

The value of manganese in such instances is twofold, and foremost of these is deoxidation; the other, already referred to, is dispersion of sulphur which appears to be absorbed in greater quantities under these conditions. The effect of manganese on shrinkage is obscure; as a carbide it becomes part of the cementite and therefore should be considered theoretically as a factor which induces an increase. Bardenheuer, Ebbelfeld, and other research workers have shown, however, that manganese increases the gas solubility of iron and as a result a partial release or expansion takes place during the solidification period and this phenomenon is credited with having a counter-effect to increasing the shrinkage.

A number of opinions exists as to the true explanation of the influence of this metal, but it seems that this one may be correct as, generally speaking, it cannot be claimed that manganese has any marked influence on shrinkage when used in quantities around 1 per cent.

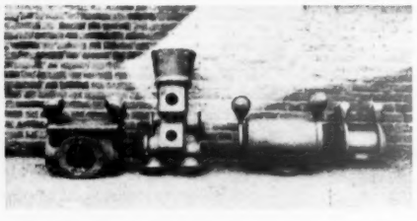


FIG. 2.—MANIFOLD CASTINGS FED BY SPHERICAL "BLOBS."

FIG. 3.—FEED HEADS USED FOR VALVE BODY CASTINGS, ETC.

FIG. 4.—FURTHER EXAMPLES OF FEED HEADS USED ON IRON CASTINGS.

Effect of Phosphorus

According to Stead, phosphorus combines with iron to form iron phosphide, which together with cementite and iron occurs as a ternary eutectic with a freezing point of 980 deg. C. The properties of phosphorus in increasing the fluidity of cast iron are well known and can thus be explained. At the solidus point, which is generally accepted to be 1,130 deg. C., the solution of iron and carbon solidifies; phosphide eutectic, on the other hand, is still fluid according to its freezing point 180 deg. C. lower. With an increase, therefore, in the amount of phosphorus, so must the amount of fluid eutectic increase and the viscosity of the metal as a whole be lowered.

Cast iron of the character known as phosphoric iron has many applications in the production of intricate and thin-sectioned castings. However, the prolonging of the solidification range in the manner described proves of great detriment to the promotion of soundness in castings of varying section; the differentials in the rate of cooling thus created set up a persistent form of segregation which proves extremely troublesome in pressure work, and although a relationship occurs between the amounts of carbon and phosphorus present, it is considered inadvisable to exceed 0.4 per cent. of the latter when strength and pressure tightness are essential. Research proves that the specific volume of cast iron is increased by the presence of phosphorus, but due consideration of the previous point is conclusive in estimating the respective merits of this element.

Influence of Sulphur

Sulphur cannot be credited with having any substantial ameliorative influence on the properties of cast iron. As a deterrent to the formation of graphite and at the same time inducing local hardness and more severe shrinkage, sulphur is to be considered an impurity in the true sense of the word and should be restricted to quantities not exceeding 0.15 per cent., and only then in the presence of at least twice as much manganese.

Alloyed Cast Iron

The exploration of alloyed cast irons and the influence of the various alloying metals in relation to shrinkage cannot be undertaken at length within the scope of this Paper. Nevertheless, as this field of development is increasing in magnitude, it is thought advisable to refer at least to one of the more prominent and widely used alloying materials, namely, nickel. In quantities ranging from 1 per cent. and as high as 40 per cent., nickel, when alloyed with cast iron of suitable composition, induces some interesting changes in the physical properties and structure of the final alloy, first of all by promoting the tough pearlite or sorbite, then the extremely hard martensite, and finally the relatively soft and valuable austenitic groups. Its solubility in iron appears to reduce the sensitivity of carbide precipitation due to rapid cooling, and thus it increases the latitude of an iron which may be critically balanced to a given cross-section.

The reduction in iron carbide is also accompanied by a stabilising of the freezing point and a liberation of very fine graphite. It can be accepted therefore that the use of nickel in smaller quantities consistent with free-machining induces one or more enhanced properties, one of which is a reduction in shrinkage. The austenitic irons containing larger amounts of nickel do nevertheless possess higher shrinkage than is generally experienced in ordinary grey iron, and additional care must be exercised when producing castings in this material.

Practical Applications of Theory

Having thus traversed the stage wherein the composition of the metal has been adjusted to a point considered suitable for the mass, design and service of the finished component, it now remains a question as to what steps are to be taken in foundry practice to avoid rejection of castings through defects attributable to shrinkage.

Solid shrinkage, which commences at the freezing of the fluid metal and continues down to atmospheric temperature, is a comparatively straightforward matter, and can be provided for by taking adequate precautions to ensure that the casting is allowed sufficient freedom of movement during this period so as not to restrain the natural phenomenon of reduction in volume. Occasionally it happens that this contingency is overlooked or possibly peculiarities of design take effect; then a cracked casting can be anticipated. Foundrymen generally, however, are fully aware of such possibilities, and consequently cores and core grids are made in such a way as to be easily crushed or removed during the period of cooling. It may be stressed, nevertheless, that low-carbon irons possess a marked increase in solid shrinkage over and above the more common grades, and therefore additional precautions are necessary.

Problem of Liquid Shrinkage

Liquid shrinkage presents a more difficult problem and with iron of low carbon content demands careful thought and attention if satisfactory castings are to be produced. For example, if an iron of this character be poured into a mould in the usual way and without any provision having been made to replenish the diminishing volume of liquid, the following action will take place. The mould having filled, liquid metal is now in contact with a cooler and to a certain extent heat-conducting material which by absorption reduces the temperature of the metal.

Unfortunately, this fall in temperature occurs in a rather uncertain manner. Portions of the casting, greater in section than the mean, possess more heat and in consequence are cooled to a less extent than the remainder, and, further, this loss of heat does not take place evenly throughout any particular section of the casting but occurs as a steep temperature drop of the surfaces directly in contact with sand and a less steep fall towards the centre of the metal. This process of solidifying takes the form of small primary crystals depositing themselves on all the sand surfaces, growing and pushing their needle-like shapes farther into the remaining fluid.

It will be seen that at some time during the cooling period there is what is virtually a solid casing surrounding a fluid or pasty mass, so that with a higher rate of shrinkage in its fluid state than solid and all means of ingress closed, one or more portions of the casting will be incompletely filled when cold. Visual inspection of these areas, if the casting were broken, would show either irregular surfaced voids, a dendritic porosity, or perhaps a structure which has the appearance of each grain being separate and apparently unattached to each other, obviously a condition to be avoided. Sometimes it is necessary to revert to the use of chills or denseners, as a means of absorbing heat from certain parts of a casting so as to reduce diverging rates of cooling. Their use, however, should be associated with careful consideration as occasionally, although chiefly with the absence of adequate feeding facilities, the chill only serves to remove the porosity to a different place.

Whichever way one examines this problem of liquid shrinkage, whether in theory or in practice, the conclusion is the same and points out the necessity of providing some form of reservoir so that a continuous supply of fluid metal is available to replace that in the casting which is diminishing in volume. Rod feeding or the method of delaying the freezing of a riser so as to allow further metal to enter the casting is a practice which requires a good deal of care when applied to low-carbon irons and although occasionally it has to be resorted to, an alternative arrangement is preferable.

The simple laws of hydrostatics explain how a fluid will travel in all directions in its efforts to attain equilibrium, the pressure at any point being proportional to the height of the source. This principle applies to all castings, at least for the length of time the metal or part of it remains fluid. Therefore the natural inference is to extend the uppermost portion of the casting in the position as poured to create one or more "feed heads" of suitable size and shape so as to ensure that they are fluid internally for a longer period than the main casting.

Table I shows a series of irons graded by analysis to suit the mass and working conditions of a wide range of castings. The column on the right describes in a brief manner the class of casting for which this particular grade of iron is used. These are all produced from furnace mixtures containing steel scrap as part of the charge, using briquetted ferro-alloys to adjust the composition as desired.

The two castings shown in Fig. 1 are ammonia-gas compressor cylinders; on the left is a single 7½-in. by 7½-in. single cylinder, and the other a 9-in. by 6-in. by 6-in. monobloc. Both of these castings, it will be noted, have the "flared" type of "feed heads" of proportion suitable to remain fluid for a longer period than the actual cylinders themselves. Heads of this description are easily applied to cylindrical castings poured on end, and producers of heavy-duty cylinder liners in particular have experienced greater freedom from unsoundness since the adoption of this method of feeding. With other castings of multifarious shapes, however, a little more thought and sometimes ingenuity is required when making provision for feeding, and a different, although equally efficient, method may be adopted. Fig. 2 gives examples of feeding by means of spherical "blobs" attached to the top of the casting in positions where the section is sufficiently large to convey the additional liquid to the portions requiring it.

TABLE I.—*Chemical and Physical Properties of Principal Irons in Use.*

Mixture symbol.	T.C.	Si.	Mn.	S.	P.	Ni.	Mo.	U.T.S. Tons per sq. in.	Transverse rupture. Tons per sq. in.	Impact. Ft.-lbs. B.C.I.R.A	Castings.
S.M.N...	3.1	1.15	0.74	0.132	0.24	1.1	Nil	17.5	32.0	16.0	Cylinders.
S.M.Spl.	3.15	1.0	0.68	0.140	0.28	Nil	Nil	Not taken	Not taken	Not taken	Tex rope drive flywheels.
S.M.1	3.15	1.3	0.64	0.138	0.27	Nil	Nil	16.0	27.0	14.0	Large valve bodies, cylinder head covers, crankcases, pistons, etc.
S.M.2 ..	3.2	1.5	0.73	0.140	0.31	Nil	Nil	15.5	24.0	12.0	Miscellaneous valves, covers, condenser casings, etc.
Ni-Mo.	2.95	1.7	0.81	0.143	0.22	1.45	0.43	23.4	35.0	20.0	Small crankshafts.

All the above are average results taken from 1.2-in. dia. test-pieces.

Figs. 3 and 4 show examples of "feed heads" as applied to some smaller castings. It must not be assumed that, having provided a casting with "feed heads," a "panacea" has been established for all porosity problems. Foundry work as a whole is too full of variables to permit any such achievement. Even accepting the fact that the mould is correctly prepared to allow for feeding and the metal is of a suitable composition, many factors still remain which can seriously endanger the final issue.

Casting temperature, for instance, is of paramount importance to the production of sound castings. It is erroneous to imagine that shrinkage is minimised by pouring at a temperature just in excess of the freezing range. Hot metal is essential to give fluidity and to provide as much heat as possible for absorption by the sand, thus enabling the metal to flow evenly into position and take up further quantities from the feed head without being obstructed too quickly by a barrier of rapidly forming crystals. This apparent retarded solidification, in addition to assisting feeding, also levels off the differential rates of freezing between the outer surfaces and centre of a section and produces a more dense and even structure, a further contribution to soundness.

Position of Feeders

When determining the position to place "feeders," it is advisable to arrange where possible for the casting to be moulded with the greater section uppermost when poured, and the "feed heads" attached thereto. Observance of this rule does occasionally present some uncertainty of mind when the heavy section also happens to be a very important and extensively machined portion of the casting. However, the recommendation still stands, and in circumstances such as described the remedy lies in the provision of much machining on the top faces.

As may be expected, efforts to overcome one particular trouble in the foundry often create several others, and the decision on the manner and method of moulding in conjunction with other essential points of production is sometimes very difficult to achieve. Consequently some castings, for reasons attributed to design, have to be made with heavy section at or near the bottom of the mould, and in such cases success depends very largely on the margin of difference between the main and heavy section, together with the amount of static head existing when the casting is fluid. The greater, and to the same extent isolated, portions will have the effect of draining other parts of the casting when taking up further liquid metal during cooling, and although the ultimate result may be satisfactory, there is an equal possibility of porosity in some part of the casting, due to the removal of metal elsewhere.

Directional solidification, or the freezing of a metal progressively from the bottom of the mould to the top, would provide an excellent solution to porosity problems. It will be realised, however, that in practice this is hardly ever possible and the nearest one can approach this excellent theory is by producing the casting in the position already stated. In addition it might also be stated that top running and the successful results obtained by pouring cylinders and cylinder liners in this manner can be considered a further example of the value in progressive cooling.

(*To be continued.*)

Uralian Dunite as O.-H. Refractory

A satisfactory refractory for lining open-hearth furnaces can be prepared from Uralian dunite, according to J. W. KLUTSCHAROW and A. G. MARANZ in the Russian "Journal of Refractory Materials." Dunite consists of 36.05 per cent. SiO_2, 0.16 per cent. TiO_2, 0.21 per cent. alumina, 3.46 per cent. ferric oxides, 3.72 per cent. ferrous oxide, 45.13 per cent. MgO, 0.60 per cent. CO_2, 0.33 per cent. K_2O, 0.29 per cent. Na_2O, 9.86 per cent. chromium oxide, and 0.15 per cent. MnO; loss on ignition 9.05 per cent. Mineralogically dunite consists of 36 per cent. olivine and 64 per cent. serpentine. On suitable blending a product is obtained with good refractory properties and a high resistance to basic and acid slags. Suitable mixtures are 88 per cent. dunite, 10 per cent. magnesite, and 2 per cent. clay; also 84 per cent. dunite, 15 per cent. magnesite, and 1 per cent. clay, and lastly 75 per cent. dunite and 25 per cent. magnesite. A material of reduced porosity but increased mechanical resistivity is obtained from a mixture of 64 per cent. dunite, 20 per cent. chromite, 15 per cent. magnesite, and 1 per cent. clay.

A New Dust Catcher

During a recent visit to a Black Country iron-foundry, our representative was impressed by a new type of dust catcher which was being used for evacuating the dust from double-ended grinders. An outstanding advantage of such an installation is the elimination of duct work beneath the floor and lengths of piping to a central plant. The apparatus known as "Superior Katchall" is made by James Lister & Sons, of Owen Street, Tipton. It consists of an extractor inducing a draught of over 2,000 ft. per min. pulling through duct work terminating just beneath each wheel, and a collector. A section through this part of the apparatus is shown in Fig. 1, from which it will be seen that the dust-laden stream of air enters at A and, after passing through a linen sleeve, reaches the outlet B. At this point it is diverted downwards over a large surface of oil, which effectually traps any very fine powder which has passed through the screen. The screen should be shaken daily and the dust box emptied twice a week.

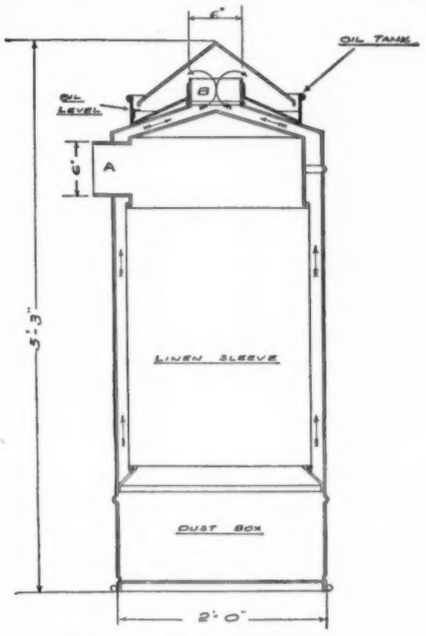


FIG. 1.—SECTION THROUGH DUST CATCHER.

Reports and Dividends

Tweedales & Smalley (1920), Limited—Final ordinary dividend of 7½ per cent., making 10 per cent.

Leeds Piston Ring & Engineering Company, Limited—Net profit to March 31 last, £2,738; brought in, £6,757; dividend of 5 per cent.; carried forward, £6,995. Meeting, June 12.

Armstrong Whitworth Securities Company, Limited—Interest on investments, bank deposits and advances, £5,602; general administrative charges, £2,994; provision for taxation, £980; net income, £1,828; brought in, £17,699; carried forward, £19,527.

Wilkes Berger Engineering Company, Limited—Net profit for 1939, £14,509; brought in, £9,846; tax reserve, £6,553; depreciation on investments in subsidiaries, £6,500; preference capital redemption, £2,250; ordinary dividend of 9 per cent.; carried forward, £1,416.

Zinc Corporation, Limited—Final participating dividend of 1s. 6d. per share on both the preference and ordinary shares, making 7s. per share on the £1 preference and 3s. per share on the 10s. ordinary shares. Also interim dividend of 2s. per share on the preference shares, being the fixed preference dividend for the year ending December 31, 1940.

Steel Obscuration Shutters

NATURAL LIGHTING POSSIBLE IN DAYTIME

To many works the efficient obscuration of windows and roof lights during the black-out period is still a serious problem. Some factories with partly glazed roofs have had them painted or otherwise covered, and the workers operate with artificial light both by night and by day. This method may ensure complete black-out at minimum cost, but it is not in the best interests of health that staffs should spend almost the whole of their working hours in artificial light. There are many alternatives to this simple but rather unsatisfactory method of preventing the escape of light such as blinds, sliding or hinged shutters, and similar contrivances, but many of them are not satisfactory, either in operation or in providing adequate daylight.

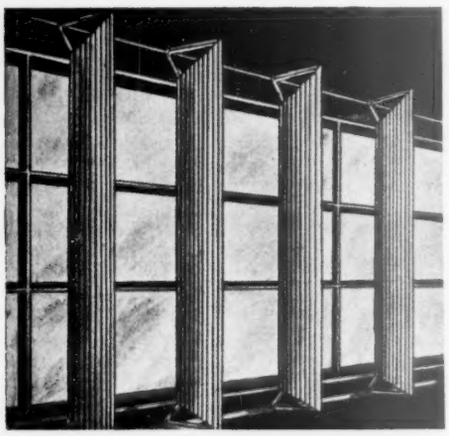


FIG. 1.—STEEL OBSCURATION SHUTTERS FITTED TO VERTICAL WINDOWS.

FIG. 2.—OBSCURATION SHUTTERS IN NORTH LIGHTS (OPEN).

One of the best systems to come to our notice is that devised and manufactured by Hills Patent Glazing Company, Limited, Albion Road, West Bromwich, Staffs, and known as Hills steel obscuration shutters. They are designed to give for all practical purposes 100 per cent. natural light combined with complete obscuration at night, and a weatherproof protection should glass be broken by concussion or blast. As shown in our illustrations the system consists of a series of shutters composed of 20-gauge galvanised corrugated sheets which are so pivoted that while they are open there is a minimum obstruction to daylight, while when closed they give a continuous light-proof covering. Moreover, as will be noticed, they can be readily camouflaged, as a means of protection when closed in the daytime during air raids.

The system can be either hand-operated or connected to electric motors, controlled from a central position. Ventilation may be provided by the provision of a dormer ventilator which can be fitted with a fan. This has the dual effect of providing ventilation and protecting the gear unit. When used to cover north lights, as indicated in the illustrations, a black gutter is formed over the top angle, either in lead or steel as suitable, and is drained off at intervals of 30 ft. by inserting a 14-gauge galvanised sheet instead of a glass pane. The corrugated sheets give one complete overlap and the installation is arranged to give a reasonably weather-proof covering should glass be broken by concussion or blast.

FIG. 3.—OBSCURATION SHUTTERS IN NORTH LIGHTS (CLOSED).

Anti-Glare Measures

CLOSING DATE FOR SUBMISSION OF SCHEMES FOR GRANT

Regulations under the Civil Defence Act, 1939, compel all works creating glare to screen this so that no glare is visible during black-out hours. Memoranda issued to all foundries in December, 1939, by the Ministry of Home Security and in April, 1940, by the British Cast Iron Research Association, gave the procedure to be adopted in securing approval of anti-glare schemes in order to obtain Treasury grant. *All anti-glare schemes on which Treasury grant is to be claimed must be submitted for approval by July* 31, 1940. In fixing this date, the Ministry of Home Security, with the concurrence of the Anti-Glare Committee of the British Cast Iron Research Association, believe that schemes can be completed before the winter without causing hardship to the firms concerned.

It is understood that the Ministry of Home Security does not contemplate that exemptions from the anti-glare provisions of the Lighting (Restrictions) Order will be granted on the same basis during next winter, and circumstances may compel the withdrawal of the exemptions still in operation.

All foundries requiring, or expecting, to operate cupola or other foundry furnaces, or otherwise creating glare, during the hours of darkness next winter must therefore install screening in order to prevent glare. Those firms wishing to obtain Treasury grant towards the expenses incurred must submit the scheme for approval by the Anti-Glare Committee of the British Cast Iron Research Association before July 31, 1940. This applies to all ironfoundries, whether they do or do not employ more than fifty persons.

A New Report

Firms who have not yet decided on the type of screening to adopt for preventing glare from the top of cupola furnaces may obtain advice on this subject from a new publication now obtainable from the British Cast Iron Research Association, 21, St. Paul's Square, Birmingham, 3—Special Publication No. 6, "Anti-Glare Equipment for Cupola Furnaces," price 2s. 6d., post free. This report describes various types of equipment which have been developed for screening glare from the top of cupola furnaces, and supersedes the sections on anti-glare screening in the earlier Special Publication No. 4, "A.R.P. for Cupola Furnaces."

In submitting a scheme for approval by the date fixed, the procedure outlined in the memorandum issued by the B.C.I.R.A. in April last must be followed. It will not, however, be essential in the first instance to submit final drawings of the scheme in order to secure approval. A rough sketch of the equipment proposed or installed, or reference to one of the schemes described in the Association's Special Publication No. 6, mentioned above, will suffice. It will, however, be necessary to give an estimate of the cost of equipment, together with details of the quantities of material required, thickness of sheets, etc. Authorisation to purchase steel for anti-glare measures must now be obtained from the Ministry of Home Security, through the British Cast Iron Research Association, on the special form which was enclosed with the memorandum issued last April. Further copies of this form may be obtained from the Association on request.

Procedure in Submitting Schemes for Approval

Firms submitting anti-glare schemes for approval *are asked to read through very carefully the memorandum issued by the Association in April,* a copy of which was sent to every firm in the ironfounding industry. Failure to follow the procedure outlined will lead to delay in securing approval of the scheme and will greatly increase the work of the Association and of the Air Raid Precautions Department of the Ministry of Home Security.

Anti-Glare Claims—The Certification of Costs

With reference to the need for an accountant to certify the cost on the claims form (see top of page 3 of the circular issued by the B.C.I.R.A. in April, 1940), the claim may be certified by any accountant who has been admitted a member of an Incorporated Society of Accountants.

Catalogue Received

Firebricks. A well-produced catalogue has just been published by General Refractories, Limited, of Genefax House, Sheffield. It definitely breaks new ground, by the inclusion of a large number of cross-sectional drawings of boiler furnaces and indicates where firebricks are used. Moreover, recommended applications of firebricks are given for all types of boilers. Our readers will probably be more interested in the large amount of technical data included in the booklet. The chemical analyses and the physical properties for many makes of firebricks are detailed, whilst the thermal expansions are illustrated as a graph. The formulæ, which have been well chosen, extend to eight pages, and especially useful are the hot and cool face temperatures for wall thicknesses ranging from 4½ to 36 in. Amongst furnaces, other than boilers previously mentioned, are blast furnaces, coke ovens, gas-producer, malleable and open-hearth furnaces. Readers who are interested in design will find the dimensioned standard shapes and sizes and the special ones, which are well illustrated, of distinct value. We congratulate the department responsible on having made a particularly creditable contribution to trade literature. The catalogue, by the way, is available on application to Sheffield.

Enamelling on Precious Metals*

By W. E. CHARLES, F.R.S.A.

Jewellery enamel closely resembles, in its composition, flint glass of which the finest tableware is made, and which is capable with various adjustments of adhering to, and decorating, certain metals. The enamels consist usually of sand, red lead, borax and soda, and vary in fusibility according to the metal on which they are used. The colouring oxides are similar to those used for colouring glass and to those used by the vitreous enamelling industry. The colouring oxides are added to the glassy material, or in most cases to the batch of glass and heated to a very high temperature, for a considerable time. For the clear crystal enamel, certain decolorisers are used to counteract the traces of iron in the sand, and for this purpose manganese, arsenic and sometimes cobalt are used to neutralise the slight green tone produced by this impurity.

The modern range of colouring oxides is much greater than that known to the ancients. Uranium, chromium, cobalt, gold, manganese, iron, etc., are employed in various forms for colouring glassy material. Great care must be taken in the manufacture to ensure that the tones remain constant, as it is very easy in the making of this coloured glass to lose all the profit in one bad melt.

The enamels are poured from the melting pots on sheets of iron to form lumps or flat cakes; they are usually sold in the lump form, but for cheaper work are supplied already ground. These cake enamels are prepared by pounding in a stoneware mortar to the fineness of silver sand, being afterwards washed to allow overground enamel, held in suspension in water, to be washed away. Good grinding and thorough washing are essentials of good practice.

Enamels are supplied already ground, but the author does not recommend this method, except where quantities are required for commercial work, and where quantity rather than quality is the prime consideration.

The enamel after grinding should have the appearance of very fine sand, with a fairly regular grain; this can only be obtained by repeated grinding and washing—the latter to eliminate the silt, and the former to obtain the regular grain. The transparent enamels should not be ground too finely, but in the case of opaque enamels this tends to improve rather than impair the final results.

After quenching and washing the enamel is ready to be applied to the ware, a small spatula or point, which consists of a thin rod 6 or 7 in. long, suitably flattened and sharpened at one end, being used for the purpose. With the end of the point, the operator picks up a blob of ground enamel and deposits it on the metal, then another blob is placed alongside the first, and so on until the surface to be enamelled is covered. The excess water is drawn off with the aid of a clean absorbent cloth, and when the enamel is thoroughly dried the article is placed in the muffle and heated until the enamel melts. It is then taken away to cool. The surface is afterwards levelled to one thickness by rubbing with a silicon carbide stone, followed by thorough washing, and the ware is then refired. For high-class work, as many as three or four coats are applied; therefore it is necessary that the enamel shall stand repeated firings. If any enamels are left in water overnight, they should be refreshed by fresh grinding before using again.

Types of Decorative Enamelling

The different styles of enamelling can be classified as follows: Cloisonné, Champlevé, Basse-Taille, Au Jour, and Limoges. It will be noted that all these titles are French; they were given to the various styles of enamelling by workers and writers of the 11th century and onwards.

The Cloisonné type is the oldest and, as far as the present knowledge goes, the original type of enamelling. The cloisons or cells are destined to enclose and retain the enamel, thus forming the design, which is made up of thin strips of flat wire of the same metal as forms the base of the article itself. In some cases the small strips of wire are held together by tiny blobs of solder.

Another method used is to glaze the base with an even coat of flux first, this being fired in the usual way, and to this is applied the wire which is held in place by a little solution of gum arabic. When the design is completed little blobs of ground enamel are carefully placed at intervals in the bottom of the cells and dried in the usual way and fired. This will fasten the wire to the flux and to the base copper. The spaces are then filled in with the various coloured enamels. During the application of these enamels a certain amount is bound to run over the edges of the wire, and this is usually rubbed off, or stoned down, gradually decreasing the abrasive material until eventually a shell-like gloss is obtained. This is the process usually carried out by the Chinese; but with the Japanese and the Russians, the final application of the enamel is usually fired after stoning down. Most of the Scandinavian countries use transparent enamels for this type of work, which is a contrast to the Japanese and Chinese work, where opaque colours are used.

Champlevé.—For this type of decoration the ground is cut out or stamped, and the space thus formed is filled in with enamel to the level of the metal. Monograms, coats of arms, and various other samples are of the champlevé style. The enamel is applied in the same way as the cloisonné, except that perhaps one can take a few more liberties with the enamelling than with the enamelling of the former.

The Basse-Taille is a development of the champlevé style, and in the author's opinion is the most beautiful of all. The ground of the design is sunk to a moderate depth, and the outlines are then carved or chased into the sunken ground. A notable example is the Royal Gold Cup of French workmanship, a beautiful exhibit of the 14th century, which was on show in the British Museum. An ingenious machine has been invented to produce this carved or chased effect on metal which, when covered with transparent enamels, produces a rich and charming effect of light and shade.

Limoges.—This is another style of enamelling which originated in France, and was extensively practised in the earlier part of the 14th century and onwards. It differs from the previous styles in that the whole of the article is made of comparatively thin copper and is enamelled both back and front. This work in simplest form consists of a thin plaque of copper, enamelled back and front, usually with a blue or black enamel. The subject, which was most frequently religious or mythological, was applied with a semi-transparent white which was partly painted and partly moulded, the parts in relief forming the highlights, while the dark ground (showing through the parts more or less thinly painted) produced the shadows. These plaques were usually set into the article in the same manner as a gem would be set into a ring. With the passage of time the introduction of more detail is noted, figures with flesh tones and pastel colours being introduced into the draperies with remarkably good effects. At this period fine gold and silver foils were introduced and were applied under the transparent enamels to heighten their brilliance. Later on this relief style began to be replaced by painting on enamel; the article was first covered with a cream or white, and pigments were painted on, fired, and coated over with transparent enamels.

Au Jour is a development of cloisonné work, the main characteristics being that there is no base to the cells, and the design is formed of thin flat wires of a suitable width, bent to the required shape and soldered together. The outer edge is of stouter material for the sake of strength, and the spaces formed are filled with enamel. The colours employed are usually of the transparent type, and the effect produced is very similar to that of stained-glass windows, only in miniature form. Another method of producing this type of work is to saw out from a piece of sheet metal the required design, which obviates the troublesome method of bending the wires into the requisite shapes and soldering them together. Various methods are employed to retain the enamel in its place while it is applied and fired. In some cases the cells are soldered on to a thin copper base which, after enamelling, is eaten away with nitric acid. It is also understood that a thin sheet of gold or silver foil may be used as a background, stuck to the metal by gum, serving as a temporary support for the enamel, and being removed by suitable means after the enamel has been fired. The whole beauty of the finished article depends on the free passage of light through the enamel. The finished articles are very fragile and are not suitable for personal ornaments.

Use of Gold in Enamelling

Gold can be used in different qualities, ranging from 9 to 22 carat. Transparent enamels are usually used on gold, to which they impart great brilliancy and richness of colour. Gold metal is also used on enamels, and is known in the enamelling industry as paillons. It is understood that enamellers have great difficulty in obtaining this metal in this country, and it is usually obtained from abroad. These paillons are placed on the enamel ground and then covered with a protective coat of colourless flux, giving a very charming effect. With regard to gold alloys, it is advantageous to use a mixture with silver and copper. The more copper there is alloyed with the gold, the less brilliant will be the results, as the copper has a

* Paper read during the exhibition organised by the Southern Section of the Institute of Vitreous Enamellers, Mr. B. B. Kent presiding. The author is on the staff of Blythe Colour Works, Limited, Cauldswell, Stoke-on-Trent.

very marked effect on the pastel shades of the enamels. As a general rule, it may be stated that pale gold gives more true colour of the enamel and greater brilliancy, but gold with a high percentage of copper will give richer results to some colours, although to the pastel shades it will give bad effects.

Eighteen-carat white gold can be successfully enamelled, and usually consists of gold, nickel, palladium, and zinc. This metal was introduced to replace platinum, actually offering a better substitute for the metal at much less cost, and is far more suitable than platinum for this purpose. Too much zinc in this alloy, however, will cause troublesome enamelling.

Silver

Silver is used extensively for enamelling on hairbrushes, scent-bottle tops, etc., and there is no doubt that the pastel shades look very beautiful when applied on silver articles. Some colours however, are affected when heated in contact with this metal. Pinks, mauves and reds can be improved in most cases by applying first a coat of flux and superimposing the colour. Different batches of silver (although of the same purity) are very different physically; in some cases this is due to the locality from which the metal was mined, in others to the method of refining which renders it unsuitable for enamelling. It is always essential, therefore, to try the metal before using it. There is an excellent silver alloy consisting of 95 per cent. silver and 5 per cent. copper on the market which has been proved very good for enamelling. There is also a very suitable substitute obtainable to-day consisting of a thin layer of silver on copper metal.

Copper

Copper or copper alloys are used extensively for commercial sign work. An example can be given of a coat-of-arms in champlevé work, consisting of 95 per cent. copper, 2½ per cent. tin, 2½ per cent. zinc. Practical enamellers are of the opinion that this is certainly the best copper alloy for large enamelling. For smaller work a higher content of zinc is used and as much as 10 to 15 per cent. is added. A well-known gilding metal under the name of Tomback is used considerably, consisting of approximately 14 per cent. zinc and 86 per cent. copper, and this is usually used for articles such as badges and small brooches. There is also another metal which is not used much in this country, consisting of copper and nickel. Up to 20 per cent. of nickel can be added to the copper, giving the parent metal a whitish appearance.

Platinum

Platinum has been left until last, as it is of little practical use to the enameller owing to its peculiar expansion and contraction. Notwithstanding the expensive nature of experiments, the author found that softer enamels are required for enamelling on platinum and that the enamel has to be very elastic owing to the peculiar contraction of this metal.

Following the Paper, a coloured cinematograph film was shown, illustrating the Blythe Colour Works and the process of production, as well as the careful tests to which the colours are subjected before despatch.

DISCUSSION

MR. A. J. BIDDULPH, commenting on an apparent suggestion by Mr. Charles that in the old days silicon carbide was used for rubbing down the enamels, said that obviously silicon carbide could not have been available in those early days. Some kind of stone must have been used for the purpose, however, and he would be interested to know what it was. He asked also what type of flux was used in welding the wires to the bases of some of the articles mentioned by Mr. Charles.

Mr. Biddulph asked for Mr. Charles's observations with regard to the small panels in clear blue enamel on the tomb of Edward the Confessor in Westminster Abbey. The panels were of about the size of a half-crown, and the enamelled surface had an appearance very similar to that of the familiar sheet-iron ground coat of the present day. They must date from the time of the death of Edward the Confessor (1066).

MR. G. REDMAN, referring to some enamelled silver hairbrushes exhibited by Mr. Charles, asked what precautions were taken to prevent oxidation of the metal when in the furnace.

Cheaper Decorative Ware

MR. J. H. GRAY, JUN., pointing out that enamel was applied to the backs of hairbrushes, hand mirrors, etc., purely for decorative purposes, asked why such precious metals as silver were used, and why that type of article was not produced more cheaply by using cheaper metals and covering them with the same form of enamel to obtain the same final result.

MR. A. G. READ said that in the Birmingham district a great deal of enamelling was carried out on ordinary bronze plates, and quite a large quantity of articles produced in that way was sold in the low-price stores. He recalled having seen those articles rubbed down by pumice stone; but he could not understand why the process of rubbing down was performed by hand, which was a laborious task, and not carried out by mechanical means.

MR. J. T. GRAY, SEN., recalled that some years ago, when he had had to deal with jewellery enamellers in Birmingham, they were using quantities of the ordinary sheet-iron grip coat enamels for the first coats; those enamels were applied on both sides of the metal, to prevent distortion of the latter, and the jewellery enamel was applied over the first coats. Much experimental work had been done in connection with that process in the past, and he wondered whether the production of jewellery in that way had been developed on a commercial basis.

Egyptian Enamelling?

MR. W. THOMAS (past-chairman of the Section) asked whether the early Egyptians had produced enamelled ware, for he had seen masks, etc., which had been taken from the tomb of Tutankhamen, and they appeared to have enamels on them.

MR. H. WHITAKER, discussing the production of the enamels dealt with in the Paper, asked what lining material was used in the furnaces in which the enamels were melted before being poured into water prior to their production in the form of a powder. He asked because he imagined that those enamels were even more corrosive than the ordinary enamel frit.

Author's Reply

MR. CHARLES, replying to Mr. Biddulph, said that obviously it would be absurd to suggest that silicon carbide was used in the early ages for rubbing down enamelled surfaces, and if he had given that impression in the Paper he hastened to correct it. When he had referred to the use of silicon carbide he had had in mind the modern methods of production.

Although he had not seen the blue enamelled panels on the tomb of Edward the Confessor in Westminster Abbey, he had read about them, and he understood that they were more or less in the champlevé style.

Replying to the questions by Mr. Redman and Mr. Gray, jun., concerning enamelled silverware, he said that when the silver was enamelled and placed in the muffle, slight oxidation occurred on the surface of the metal. When the enamel reached the fluid state, it dissolved the slight tarnish or oxide that had been formed. The enamelling of pastel shades on copper was not so successful, because copper had rather a greater degree of oxidation than had silver when heated in the muffle, and for that reason pastel shades were not usually enamelled on copper. Strangely enough, it was the practice in Birmingham to place the silver articles on trays and to give them a very slight tarnish before applying the enamel to them. When he had suggested that surely sufficient tarnish was produced on the silver in the course of the enamelling, they assured him that their method was dictated by practical experience; they had found that the slight tarnish which they gave to the metal before enamelling provided a key to the surface of the metal, and the enamel did not fall off in the absence of an outer bead to hold it in. However, one could not produce enamels of such brilliance on copper as on silver, because the rather higher degree of oxidation of the copper during firing resulted in some distortion of the pastel shades. On silver one could apply pastel shades and could secure the real brilliance of the undercoat and the chased effect of the engine turning.

He assured Mr. Read that in factories in Birmingham where large quantities of cheap badges and other enamelled articles were produced daily, the rubbing down was effected by machines. The rubbing down of high-class work was done by hand, however, for it required the manipulation of an artist.

Dealing with the question of Mr. Gray, sen., as to the use of ordinary frit as a backing flux, *i.e.*, applying it to the metal to counteract the expansion of the surface enamel that was applied subsequently, he said that, provided the backing enamel was slightly softer than the surface enamel, he could see no reason why it should not be the ordinary frit; in fact, he had used it quite satisfactorily for that purpose. Many of the enamellers were rather conservative and preferred to use backing enamel of more or less the same composition as the surface enamel. He had found that as a rule—although he would not like to say that it was a permanent rule, because his experience had been so contradictory—one could use a leadless enamel on the copper and silver ware.

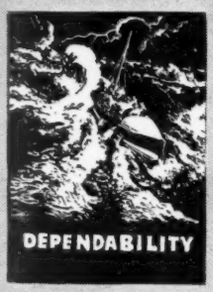
In reply to Mr. Thomas, Mr. Charles said he had been informed by a high authority at the British Museum that there was no proof that enamelling was practised by the Egyptians. Certain articles had been found, made as long ago as 3000 B.C., but they were articles of glazed pottery ware, and so on. Articles which had been regarded in some quarters as enamelled metal ware were in fact composed of metal into which coloured glasses had been fitted. In the tomb of Tutankhamen (1300 B.C.), there were some examples of that particular style; coloured glass had been embodied in the metal, but it had not been enamelled: it had not been fired.

The composition of the linings of the furnaces in which the enamels were melted varied considerably. His company had made crucibles consisting of a Staffordshire clay, some grog and some alumina, but he could not say what was the composition of the more resistant grades. He suggested that Mr. Whitaker might be able to obtain information from the makers. The normal prescription was clay and grog, and those materials must be mixed very finely, otherwise the linings were apt to spall during the firing.

Vote of Thanks

MR. J. T. GRAY, SEN., proposed a very hearty vote of thanks to Mr. Charles for his unusual and interesting Paper, and for the very fine exhibits he had displayed to illustrate it. Confirming the author's reference to the oxidising of silver surfaces before enamelling, he recalled that many years ago he had had the privilege of installing plant for Mr. Fisher, the eminent craftsman-artist in the enamelling of jewellery. The plant had included a muffle having a small hole at the back; but Mr. Fisher had wanted it closed completely, because he had wanted to produce a slight oxidation on the metal before applying the enamel, his reason being that that

(*Continued on page* 424.)



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The Week's News in Brief

Trade Talk

THE INSTITUTION OF AUTOMOBILE ENGINEERS have cancelled arrangements for an Institution luncheon to be held on June 21.

THE BRADLEY PULVERIZER COMPANY are moving from 37, Walbrook, London, E.C.4, to 27, The Albany, Britannia Square, Worcester.

A CENSUS of the working hours of all machine tools operating in the engineering and allied industries in Great Britain and Northern Ireland is being made this week, at the request of the Production Council.

THE NET PROFIT of the International Nickel Company of Canada, Limited, for the three months ended March 31 was $9,820,114, equivalent after preferred dividend requirements to 64 cents a share on the 14,584,025 no par shares of common stock outstanding.

THE LIMITATION OF DIVIDENDS BILL is to be dropped, it was announced by Sir Kingsley Wood, speaking in the House of Commons on Tuesday. This action is regarded as a natural sequel to the decision to apply the 100 per cent. Excess Profits Tax to all firms instead of only to those under Government control.

J. GRAY & SONS, LIMITED, have removed their offices from 5, Victoria Street, London, S.W.1, to Paisley Works, Swains Road, Tooting, S.W.17, so that they are now established at the works of their associated company, J. F. Stewart & Company, Limited. The object of the removal is to expedite the conduct of correspondence and the handling of orders.

THE MINISTRY OF LABOUR AND NATIONAL SERVICE requests professional engineers who are enrolled on the Central Register and who are immediately available for national work in their professional capacity, to send a postcard to that effect with their full name, address, and telephone number, to the Central Register, Ministry of Labour, Tothill Street, Westminster, S.W.1. This information will be of value to the Minister in making his arrangements for the rapid expansion of engineering production. Further announcements will be made in due course about professional engineers who are not at present registered with the Ministry of Labour and National Service.

NEW arangements designed to co-ordinate British demands on United States machine-tool builders have been made. The object is to obtain the maximum possible deliveries of machine tools with the minimum possible upset of prices and delivery dates. The scheme provides that all purchases of new machine tools in the United States for British needs will be made by the British Supply Board in Canada and the United States. Those in the United States are to be made on behalf of the Board by the British Purchasing Commission which operates under the instruction of the British Supply Board. Buyers will follow normal commercial practice in so far as contracts with agents —importers who have been registered under the new scheme—are concerned. All orders must be sponsored by a Government department, public-utility company, or local authority. The Controller of Machine Tools, Ministry of Supply, with whom agents must be registered, has sent a circular to all Government departments and importers of machine tools giving details of the arrangements.

A MEMORANDUM issued by the Board of Education urges technical schools and colleges to assist in the war effort by concentrating on the production of gauges and jigs which are used with vast numbers of machine tools in the armament industry. Without a sufficient supply many machine tools would stand idle. The Board are satisfied that many of the parts required could be manufactured in the workshops of technical institutions, either as exercises for trainees and students or directly by the college staff, assisted by recruited labour, male or female. Institutions less well equipped could fashion the parts roughly to size, passing them on to better equipped colleges for finishing. Much of the preliminary work could be done by junior technical students or by semi-skilled trainees. Schools are asked to consider keeping their workshops open after the school work is over for as many hours out of the 24 as can be organised. Shifts of workers or evening shifts might be arranged and the workshops run during these periods as a factory. The usual commercial rates will be paid by the Government department concerned for all that is produced.

Obituary

LIEUT.-COL. P. A. KIRSOP, senior partner in the firm of A. B. Kirsop & Company, iron and steel merchants, Glasgow, has been killed in action.

MR. J. H. ARMORY, a director of Wilson's Forge (1929), Limited, steel founders, of Bishop Auckland, Durham, died recently in Darlington, aged 61 years.

MR. H. H. B. PEARCE died last week at his residence at Selly Oak in his 79th year. Mr. Pearce was a member of an old Smethwick family. For many years he was chairman of the Midland Motor Cylinder Company, Limited, and he had continued to serve as a director.

MR. W. J. MCLACHLAN, who was works and commercial manager of the heavy foundry of Carron Company, Carron, until the summer of 1936, when ill-health compelled him to retire, has died. He had been associated with Carron since 1906, prior to which he had had foundry experience in Spain and in Airdrie, of which town he was a native.

MR. JOHN FREDERICK IVOR THOMAS, managing director of British Jeffrey-Diamond, Limited, mining engineers, of Wakefield, died in a Bournemouth nursing home recently. Mr. Thomas was known at home and abroad for his great engineering knowledge and qualities as an administrator. During the last war, he carried out important work for the British Government in America. For a time he was connected with Vickers, Limited. He had travelled on business to Canada, Nova Scotia, Russia and South Africa. He joined the board of British Jeffrey-Diamond, Limited, as managing director about seven or eight years ago.

Personal

SIR JOSNA GHOSAL has been appointed a director of the Steel Corporation of Bengal, Limited, in place of Sir P. P. Ginwala.

THE ENGAGEMENT is announced of Mr. John Durrans, of the firm of John Durrans & Company, Phoenix Works, Penistone, foundry facings manufacturers, to Miss Z. S. Wordsworth, of Pontefract.

SIR WALTER LAYTON has been appointed to be Director-General of Programmes in the Ministry of Supply, and to be a member of the Supply Council. Sir Walter Layton was a member of the Munitions Council in the Ministry of Munitions during the last war.

MR. ALBERT WILDMAN, works manager of Whittaker Bros., mangling and washing machine manufacturers and ironfounders, Accrington, Lancs, for eighteen years, has been appointed to a similar position at the Keighley (Yorks) works of the Co-operative Wholesale Society, Limited. He has received a presentation from the directors of Whittaker Bros.

Wills

ELLIS, JOSEPH, of Keswick, formerly managing director of the Workington Iron & Steel Company ...	£45,424
GARDNER, C. E., chairman of William Gardner & Sons (Gloucester), Limited, engineers and ironfounders	£35,951
CROSSLEY, A. C., M.P. for Stretford, Lancs, since 1935, a director of Crossley Bros., Limited, and of Crossley-Premier Engines, Limited	£9,565

Contracts Open

Ely, June 18—Providing and laying 410 yds. of cast-iron water pipes and lead service pipes, for the Ely Rural District Council. Mr. F. W. Green, clerk, Council Offices, Ely.

Faringdon, June 15—Supply and laying of approx. 395 yds. of 6 in. dia. spun-iron rising water main, with pipe bends, cast-iron specials, etc.; supply and erection of approx. 84 yds. of wire fencing and concrete posts, for the Rural District Council. Mr. K. M. Hart, engineer and surveyor, Council Offices, London Street, Faringdon, Berks. (Fee £4 4s., returnable.)

Tenby, June 22—Construction of about a mile of 10 in. dia. and about 20 miles of 9 in. dia. spun-iron water main, for the Corporation. John Taylor & Sons, engineers, Caxton House, Westminster, London, S.W.1. (Fee £5, returnable.)

Company Meetings

Beyer, Peacock & Company, Limited

At the annual meeting of Beyer, Peacock & Company, Limited, CAPT. HUGH VIVIAN (chairman) said that the profit for 1939 would have been considerably higher but for the outbreak of war in September. Had the company been free to pursue its normal operations its export order-book of locomotive contracts was of ample size to ensure a prosperous year. There was a good deal of misinformed or uninformed opinion as to the profitability of armament contracts in the engineering trades. Beyer, Peacock & Company were considerably worse off financially as a result of the inevitable dislocation of normal trade. In spite of the fact that for the period of the war the company's order-book and activity were both expected to be high, the board took the view that during this period the rate of profit would depend on a number of factors, some of which were outside the control of the company.

Newton, Chambers & Company, Limited

The annual meeting of Newton, Chambers & Company, Limited, was held in Sheffield on May 29. SIR SAMUEL ROBERTS, BT. (chairman), said during his address that the profit from the ironworks had been satisfactory, and almost the same as for the previous year. Everything possible was being done to assist the national effort, but they still were able to take some orders in their ordinary lines of business, which, if not directly for Government work, indirectly assisted the national effort. During the year the volume of orders taken was the highest in the history of the ironworks.

Basic Open-Hearth Slags

According to W. P. REWEBZOW in "Uralskaja Metallurgija," the quality of basic open-hearth slags can be determined by means of viscosity measurements using the C. H. Hertz, jun., viscosimeter. With basic slags in which the ratio of $CaO:SiO_2$ is greater than 1.44 to 1.67, measurements can only be carried out with the addition of from 1 to 1.5 per cent. bauxite, so that the slag contains 5 to 7 per cent. alumina.

Forthcoming Events

Institute of Vitreous Enamellers

JUNE 11.

Extraordinary General Meeting:—To consider alteration of Articles of Association, at Chamber of Commerce, New Street, Birmingham, at 2.0 p.m.

Institute of British Foundrymen

JUNE 13.

East Anglian Section:—"Pig-iron Production," by H. A. Fox, at Central Library, Ipswich, at 7 p.m.

Enamelling on Precious Metals

(*Continued from page* 422.)

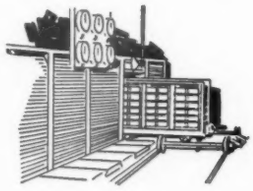
oxide went into suspension in the enamel subsequently and provided a key.

Mr. Gray added that, having himself visited many museums and inspected examples of early enamelling, he appreciated that this work was very tiring and called for the sacrifice of a great deal of time. It was obvious that Mr. Charles had devoted considerable time to the preparation of his Paper and the collection of the material it contained, and the meeting was grateful to him.

MR. H. CAMERON, seconding the vote of thanks, recalled having seen in the Victoria and Albert Museum a style of enamelling named "Aventurine," and he suggested that it would be a fine thing to be able to reproduce it in vitreous enamel in the future. He had tried to do so, but had failed, and he expressed the hope that Mr. Charles's experiments might show the way to reproduce it in the future.

The vote of thanks was accorded with acclamation, and MR. CHARLES, in a brief response, confessed that he had become very greatly interested in the work with which the Paper was concerned, and he expressed the hope that some of those attending the meeting would be sufficiently interested to experiment.

REFRACTORIES ON PARADE



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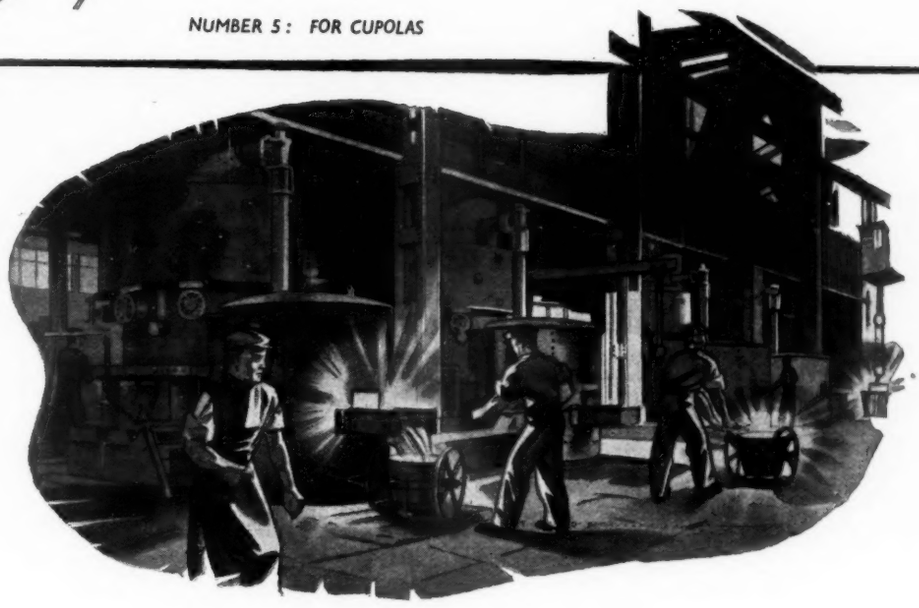

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Raw Material Markets

The recent marked expansion in the output of munitions, which the Minister of Supply has been able to report, is in no small way due to the efforts of the iron and steel industry. Since the formation of the new Government and the drive to increase still more the production of iron and steel, the works have shown their eagerness to co-operate with the new administration and to play the part which must be demanded of the trade in existing circumstances. The demand for high-phosphorus iron continues to be rather below normal, but it is likely that consuming industries will later have a bigger share in Government orders than has so far come their way; if this is so an expansion of outputs will be necessary, as stocks are not high either at makers' or consumers' works, although they are quite sufficient to meet the demand which has been forthcoming for some months past.

Pig-Iron

MIDDLESBROUGH—Adequate supplies of foundry iron are being delivered from the Midlands works to consumers in the Cleveland area, which is fortunate, as the latter are relying almost solely on their outputs, owing to the cessation of the production of iron of this quality in the Middlesbrough district. Furnaces here are engaged on the manufacture of steelmaking iron, for which there is an insatiable demand. Increasing numbers of furnaces in the Midlands are also being transferred from the production of foundry iron to iron for the steelworks, and so the supply of the former may become difficult in the future.

Apart from the strong demands of the steelworks for hematite, there is a good call for iron from other users, and the full output of the makers is passing immediately into consumption. The needs of the steel plants are, of course, given preference, but fair deliveries are being made to other users. The allocation of supplies is difficult, as, in addition to local users, works in the Midlands and Sheffield obtain their requirements from the North-East Coast.

LANCASHIRE—Pig-iron users in this area have generally been acquiring adequate tonnages to enable them to operate their plants satisfactorily, but it is understood that a scheme is now under consideration for the more rigid distribution of iron; this is not engendered by any shortage, but is a necessary precaution to prevent material being used for work not essential to the war effort. Most of the ironfoundries in this district are busy, but conditions in the light-castings trade are far from satisfactory, while some jobbing foundries are not well placed, being only intermittently employed. Other consumers, especially the speciality engineering concerns, are fully engaged on Government contracts, and are responsible for a large consumption of iron. Lancashire consumers of West Coast hematite are taking up steady tonnages.

MIDLANDS—Short time is still occurring at many light-castings works, and it does not appear likely that there will be much improvement unless Government orders are placed with these concerns. This question is still a matter for conjecture, but it is noticeable that Government departments are making inquiries as to the capabilities of light-casting works in all parts of the United Kingdom. At the moment, however, the best that can be said for this trade is that it might be a useful reserve source of strength later in the war. Makers are receiving very few orders for building trade requisites, while the loss of the export trade has hit the industry very severely and can only be regained slowly. Licences for iron for ordinary domestic uses are not now being granted. Heavy engineering foundries, being very actively engaged on Government work, are taking up large tonnages of low-phosphorus iron and hematite, together with a very much smaller quantity of high-phosphorus iron. The position as regards supplies of both low-phosphorus iron and hematite is still improving, although there is no surplus.

SCOTLAND—The tone of the light-castings trade in the Falkirk district has improved following the placing of some Government orders, but, as yet, only the surface has been scratched, and before the trade can hope to return to anything approaching peace-time conditions, orders from Government departments will have to be very much more substantial. Nevertheless, producers appreciate the co-operation of the Ministry of Supply and are hoping that the future holds in store for them more business than has come their way since the outbreak of war. Other iron consuming industries in this area are very busy.

Coke

As announced in our last issue, the price of Durham and Welsh foundry coke has been advanced by 2s. 6d. per ton, making the current quotation, for delivery to Birmingham and Black Country stations, 55s. 6d. per ton. No date has been put forward by the Control for a revision of this figure, and adjustments will be made whenever the authorities consider the position warrants a change. The higher price, which was universally expected by consumers, was due to the introduction of higher rail charges and also to the increase in the price of coking coal, 1s. of the new quotation for foundry coke being attributable to the latter cause.

Steel

Working time at steelworks everywhere is being increased, and larger outputs are being produced as a result. Distribution of finished steel is now entirely controlled, and any consumer wishing to obtain additional supplies must first acquire permission to do so. In this way available supplies are ensured of being put to the best use. There is little consumption of steel for anything but war work and in order to acquire material for domestic purposes the buyer must have a concrete case to put before the authorities. In view of the stoppage of supplies of steel semis from Belgium, it is hoped that tonnages of a substantial character will shortly be arriving from the United States.

Scrap

Judging from recent efforts, it would appear that the nation's need for scrap iron and steel is becoming more widely appreciated; local authorities and householders in all parts of the United Kingdom are co-operating in the effort to secure the transmutation of scrap into munitions, and large deliveries are being made weekly to consuming works. "Scrap weeks" are being held in many towns and cities, the results generally being good. The importance of scrap metal being placed in the right hands is being impressed upon the public, who are responding by turning out all their metal, much of which has not served any good purpose for a long time past. In Sheffield, scrap merchants are being assisted in the collection of the metal by local organisations, while in Middlesbrough a "scrap week" is to be held, starting on June 17, under the auspices of the North-East Association of Iron and Steel and Metal Merchants. Householders are being asked to give their scrap, where possible, and the proceeds will be devoted to charities. Such efforts as these appeal to householders, and are likely to be adopted in other places. The Ministry of Supply is organising "old iron" dumps in villages and hamlets.

Metals

News of substantial purchases of copper by Britain and France has come to hand during the past few days. It is announced from New York that the British Government is seeking 20,000 to 25,000 tons of copper for immediate shipment. Of this amount about 10,000 tons have already been purchased at slightly above 11.50 cents per lb. Earlier it was reported that virtual agreement has been reached for the purchase by France of an additional 75,000 tons of copper from the same group of mines outside the United States, but principally American owned, which had been supplying France's wartime requirements. This will make total purchases by our Ally to date of $100,000,000 and 375,000 tons. Allied consumption of the red metal is, of course, exceptionally heavy and is steadily increasing. Empire sources are delivering metal on a huge scale and it is expected that the Ministry of Supply will enter into additional contracts with Canadian producers shortly.

The total visible supply of tin on May 31 was 25,632 tons, against 23,119 tons at the end of April, according to Mr. W. H. Gartsen (Henry Rogers, Sons & Company). The carry-over in the Straits Settlements was 2,451 (4,564) tons; owing to the invasion of the Low Countries, it has not been possible to state the carry-over at principal European smelters, but on April 30 the figure was 3,616 tons.

A certain amount of nervousness regarding future tin supplies is apparent in the United States and the Government is being urged in some quarters to increase tin purchases as a precautionary measure. Discussing the tin position in the United States C. S. Trench & Company, Inc., of New York, suggest that to be on the safe side, the American Government's emergency stocks should be the equivalent of one year's normal consumptive requirements, whereas purchases to date would not carry the country for more than about three weeks. (It is claimed in certain quarters, however, that in the event of America becoming involved in war, her tin stocks would probably last for as long as three months.) Why Congress, after approving the expenditure of $100,000,000 for the acquirement of critical strategic materials over a period of four years has not voted the money to carry out the programme, is one of those strange things which is hard to explain—especially with world conditions as they are to-day, Messrs. Trench comment. Recently, Senator Townsend introduced a Bill to appropriate $500,000,000 for the purchase of strategic materials, the money to be taken from the unused portion of the Stabilisation Fund, but it is understood that the administration opposes this Bill for monetary reasons—whatever that means. Nevertheless, the administration does favour a liberal accumulation of those articles requisite for national defence. As there are no tin deposits in the United States capable of development, tin can be classified as strategic material number one and Messrs. Trench believe that money will be found somewhere to enable the Procurement Division to make much more liberal purchases during the next six months than during the last six months.

London Metal Exchange tin prices this week have been as follow:—

Cash—Thursday, £273 10s. to £273 15s.; Friday, £274 15s. to £275; Monday, £276 10s. to £277; Tuesday, £277 to £277 5s.; Wednesday, £275 10s. to £275 15s.

Three Months—Thursday, £271 5s. to £271 10s.; Friday, £273 to £273 5s.; Monday, £274 5s. to £274 10s.; Tuesday, £274 15s. to £275; Wednesday, £273 10s. to £273 15s.

Consumption of spelter in the United Kingdom continues to be very heavy and the loss of production in Belgium and the North of France has already been followed by purchases in America. Control of the seas allows the Allies to buy their requirements where they will, Greater Germany, of course, excepted, but longer transport and increasing use of shipping space is not to be encouraged unless the position is urgent. The lead position is somewhat similar and Allied interest in Mexican metal may be expected.

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